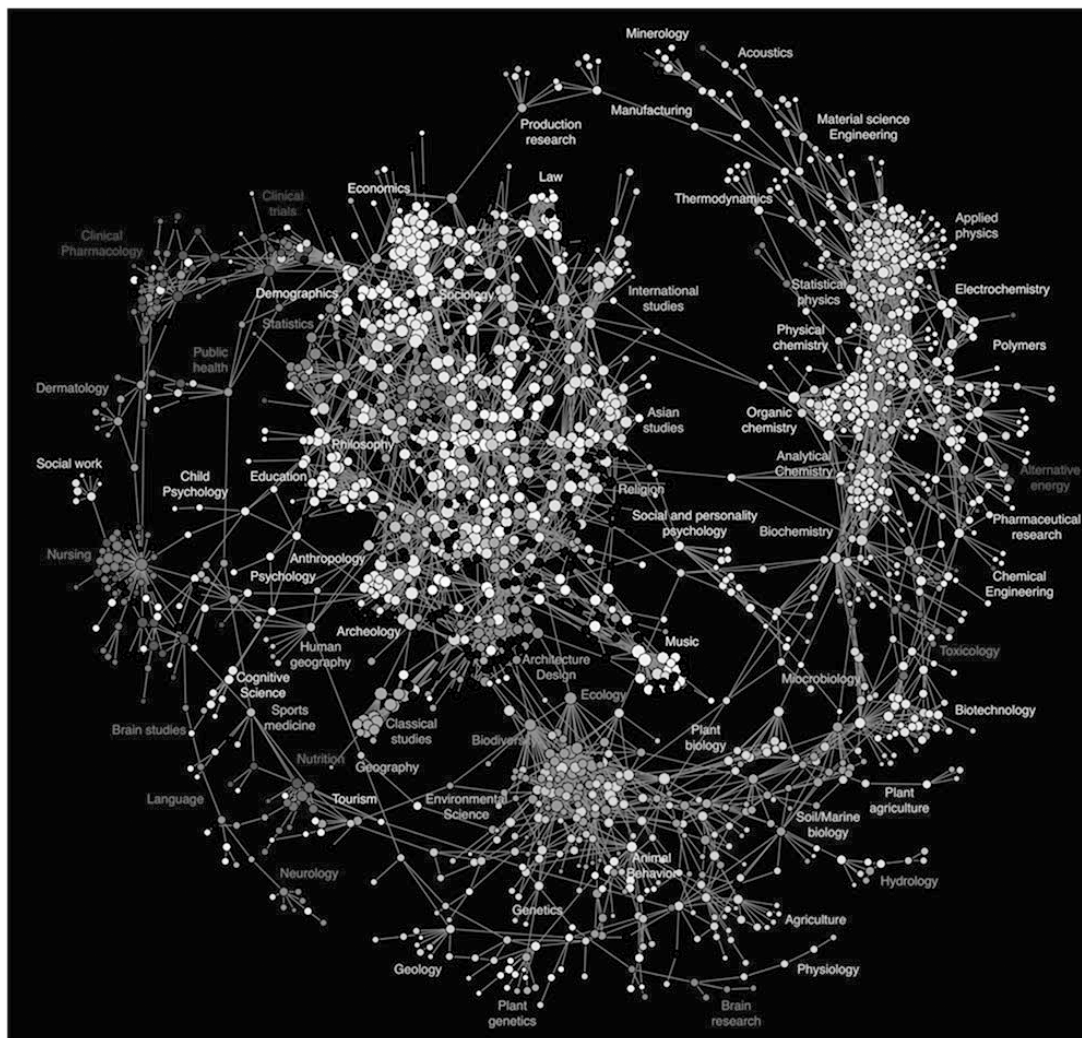# Steps to an Ecology of Networked Knowledge and Innovation

Enabling new forms of collaboration among sciences, engineering, arts, and design

VOLUME II: Meta-analyses, abstracts, and White Papers

Prepared by Roger F. Malina, Carol Strohecker, Carol LaFayette, and Amy Ione
on behalf of the SEAD Network White Papers Steering Group and 200 White Papers contributors

August 9, 2013

Steps to an Ecology of Networked Knowledge and Innovation: Enabling new forms of collaboration among sciences, engineering, arts, and design

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Volume II

Introduction to Volume II

This volume collects all the international community inputs received in response to the call for SEAD (Science, Engineering, Arts, and Design) White Papers. In Volume I, we have described the overall methodology for working with the international community, aiming to benefit from their experience and ideas about how to advance SEAD practices in the coming years (see Volume I, SEAD White Papers Methodology). All of these White Papers are available online at the SEAD website (http://seadnetwork.wordpress.com/white-paper-abstracts/).

This Volume II includes web links to each of the White Papers.

The process for researching and crafting the SEAD White Papers Report relied on the collaborative nature of the SEAD network. This community of advocates is united by a vision of the importance and value of research and creative work spanning and joining the arts and sciences. Initially, two groups received concurrent NSF EAGER grant funding: NSEAD and XSEAD. NSEAD (now SEAD) proposed the White Papers initiative as a way to build community around perceived challenges and opportunities in broadly transdisciplinary work. The White Papers Working Group became the mechanism for conducting this research on behalf of and in collaboration with the network. Through efforts of the Working Group, we have been able to solicit Suggested Actions, structure them according to similarities of motivation and purpose, and make them relevant to stakeholders.

Working with an internationally renowned advisory board, SEAD Principal Investigator Carol LaFayette and the White Papers Working Group Cochairs Roger Malina and Carol Strohecker wrote and released a call for papers to incorporate the ideas of active professionals, ensure that the proposed outcomes would benefit the diverse SEAD population, and draw both primary experiences and secondary research into the analysis. In addition, they asked authors to provide "Suggested Actions" that indicated how their ideas could better involve stakeholders and inform other SEAD initiatives.

In response to this call, authors submitted 73 abstracts, 55 full White Papers, and 260 Suggested Actions. The breadth and diversity of the authors and the topics they examine offer a window into the current landscape of collaborative art, science, technology, and design.

As part of our White Papers methodology, we issued an open call to all the SEAD White Papers authors to contribute to the final report via a "meta-analysis" of the White Papers. The goal was

to develop a meta-analysis methodology yielding an overall portrait, or synthesis, of the state of mind of the SEAD community internationally.

Although generating sufficient statistics was not a goal of the SEAD White Papers initiative, a Suggested Action for a "Beyond Productivity II" report would be to do so. The meta-analysis employed here uses research synthesis and systematic review as well as purely statistical evaluations, but by viewing the 55 White Papers as a single text it is possible to use meta-analysis approaches (e.g., keyword frequency).

Four meta-analyses were added to the project when interested parties noted gaps in the White Papers collection. This collection also met one criterion of the project: The SEAD community of practice should be self-critical and self-analytic using the tools and data now available on our own behaviors and practice.

These meta-analyses are posted at http://wp.me/P2oVig-qa. The authors and titles follow:

- Gabriel Harp, "SEAD Themes and Insights Meta-Analysis: A Minority Report."
- François-Joseph Lapointe, "A SEAD Network Analysis of White Papers."
- Cristina Miranda de Almeida, "Meta-Analysis of SEAD White Papers with Focus on Research and Creation."
- Jonathan Zilberg, "A SEAD White Papers Working Group Meta-Analysis."

We have included the insights provided by these papers in the 13 Suggested Action clusters in this report. Some points raised by these authors are worth emphasizing:

1. The C. P. Snow "two cultures" thesis is again revealed as a flawed conceptual framework.
Both Lapointe and Zilberg, using different approaches, conclude that today's SEAD community of practice demonstrates that the persistent "two cultures" framing of the situation is neither accurate nor useful. In a detailed network analysis of 40 of the White Papers, Lapointe demonstrates that the data do not support a "two cultures" description of the actual research and practice networks; in addition, he highlights the existence of a large cohort of "artscientists" whose practice merges the cultures and, accordingly, who cluster in the network analysis. The paper reveals the power of network analysis for the study of intertextual comparisons and exemplifies methods for research using social and textual analytics. Zillberg points out that many of the SEAD White Papers authors problematically assume a "two cultures" premise and reflect it in their discourse. He asserts that this

insufficiently questioned premise significantly compromises the SEAD network's potential. The title of our report, "Steps to an Ecology of Networked Knowledge and Innovation" is a constructive attempt to shift the paradigm of SEAD discussions beyond a "two cultures" premise.

2. SEAD practitioners should be cautious about describing the impact of their work on science.
In analyzing more than 20 of the White Papers, Zilberg issues a note of caution about the value of SEAD research in enabling new scientific discoveries. He notes that cross-disciplinary work can and does contribute to scientific creativity and science education. However, he argues that in terms of the most basic and direct criteria, SEAD cannot yet be seen as a fully transdisciplinary agenda because it has not been demonstrated that the arts can contribute in a systematic manner to basic science. Nevertheless, it is possible that SEAD-style projects have inspired scientific work. It seems, he concludes, that not only is clarity required about the nature of the disciplinary relations, but perhaps some basic research should be conducted to look into their particular contributions and effects more closely. Nevertheless, it is worth noting that several scientists participating in the study by Strohecker et al. describe ways in which arts and their work with artistic collaborators have influenced their scientific thinking, discoveries, and inventions. Notably, Zilberg does not entertain the inverse of his argument to assert that, likewise, basic science can contribute in a systematic manner to the arts. Presumably, the research he proposes would aim to achieve this sort of symmetry – all the while, of course, transcending "two cultures" pitfalls to explore genuine disciplinary integrations.

3. Converting "Suggested Actions" into "Process Strategies."
Harp and Miranda de Almeida provide in-depth alternative analyses of the 260 Suggested Actions in the SEAD White Papers. Harp derives 41 action areas, grouping insights into the domains of people, platforms, and practices. He notes that Tardif and Sternberg (1988) present similar themes, identifying processes, persons, products, and places as important clusters of focus for creativity research. Miranda de Almeida analyzes from the perspective of Theory of Action; her methodology (developed together with Tejerina, her White Paper co-author) offers a tri-dimensional matrix to deal with six different kinds of action, four kinds of stakeholders, and four spheres of integration/collaboration.

The meta-analyses also contribute constructively to the rationale that motivates the overarching Suggested Action that the time is ripe to initiate a "Beyond Productivity II" study and report, aiming to accelerate SEAD agendas.

Who are the authors?

White Papers were written by one lead person (coordinator) or included a group of interested people (a working group) coordinated by a lead person. While some participants/authors developed their abstract as the work proceeded, all the participants needed to endorse the final paper.

What was the process?

Not all submitted abstracts resulted in a White Paper, although the abstracts also included Suggested Actions. Professionals from the SEAD community were a part of the research and review process to insure that the proposed outcomes would benefit the SEAD cohort overall. We intentionally viewed the White Papers as living documents posted in an open-access website and posted improved versions of the papers as we received them.

What is the scope?

We requested that authors include roadblocks and opportunities for enabling broadly interdisciplinary work. Our goal was not to examine interdisciplinary work in general, but rather what is happening in the SEAD context. In presenting this perspective, we made it clear that SEAD assumed a broad view of the Arts to include not just materials-based creativity, but also liberal arts such as the Humanities.

International perspective

Our call for papers specifically stated that we were interested in including an international perspective in the planned meta-analysis of the White Papers, although the scope of specific papers did not need to include international collaboration issues. This resulted in many papers from authors around the world. The demographics provided in Volume I, Appendix 6, indicate the level of success in getting an international snapshot of the state of SEAD studies. We recognize, however, that our results are dominated by the English-speaking world in a way that does not reflect the community of practice itself. In addition, the low representation from outside North America and Western Europe does not reflect the vitality of work currently going on in

Eastern Europe, Asia, Central and South America, and Africa. We were able to achieve a respectable breadth of international inclusion within the timing of the initiative, but even greater cultural diversity could become possible in a follow-on effort with expanded resources and parameters.

Purpose of the White Papers and the role of stakeholders

The call for papers requested proposed actions and specific stakeholder information. We emphasized that Suggested Actions were intended not for the National Science Foundation, the funder of the project. Rather, the authors' focus was to be on the broader landscape of stakeholders and beneficiaries of their SEAD initiatives. These groups might include a variety of agencies, foundations, educational institutions, nonprofits, or other "agents." Similarly, although the White Papers initiative was not an effort to claim that art advances science or vice versa, individual authors did express such points of view. The SEAD network has given voice to these practitioners individually and collectively.

We defined stakeholders as consumers of specific products or technologies, government agencies, SEAD students and professionals, and all who have a vested interest in SEAD success. Thus the intention was to extend the analysis beyond academia and include, for example, businesses and municipal economic development councils.

Authors did not need to address *all* stakeholders. The idea was that each paper's proposed actions would clearly address specific stakeholders, identify barriers and opportunities, and recommend strategies. This flexibility allowed for responses that were relevant outside of academic contexts, as well as those having implications for curriculum development.

Summary

The final White Papers (posted at http://seadnetwork.wordpress.com/white-paper-abstracts/final-white-papers/) represent a spectrum of interests in advocating for transdisciplinarity among arts, sciences, and technologies. All authors submitted plans of action and identified stakeholders they perceived as instrumental in carrying out such plans. The individual efforts led to an international scope. One of the important characteristics of this collection is that the papers do not represent a collective aim toward an explicit initiative. Rather, they offer a broad array of views on barriers faced and prospective solutions.

In summary, the collected White Papers and associated meta-analyses began as an effort to take the pulse of the SEAD community as broadly as possible. The ideas they generated provide a fruitful basis for gauging trends and challenges in facilitating the growth of the network and implementing future SEAD initiatives.

SEAD THEMES AND INSIGHTS META-ANALYSIS: FROM CONFLICT TO COHERENCE

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Introduction

The following survey of insights was developed for the Network for Science, Engineering, Art and Design (SEAD) White Papers project. Its goal is to raise awareness of the impacts, values, opportunities and challenges of cross-disciplinary research and creative work.

The SEAD project solicited White Papers contributors and asked for Suggested Actions around advocacy and collaboration with the goal of fostering innovation, learning, community sustainability, and economic development. White Papers contributors provided an array of comments and Suggested Actions, and I have tried to synthesize many of them here. The White Papers submissions and more information about the project can be found at the SEAD White Papers project's website http://seadnetwork.wordpress.com/about/.

Approach

A qualitative survey of the White Papers was undertaken by 1) identifying relevant themes, insights, and concepts from each submission, 2) clustering similarities and differences, 3) identifying patterns, and 4) researching the literature for frames reference that could bring coherence to the range and diversity of themes presented. Several overarching concerns were identified by the White Papers authors: (1) equity and identity among disciplines and stakeholders, (2) funding resources, (3) workspaces, and (4) process and common ground.

To build on the emerging themes presented in the White Paperss, I grouped insights into the broad domains of *people, platforms, and practices*. Similar themes are presented by Tardif and Sternberg (1988) who identified processes, persons, products, and places as important clusters from a corpus of research on creativity. Similarly, in the emerging literature of social practice and innovation, Shove et al. (2012) have gone a step further, describing in detail how the dynamic interactions of *meaning, competencies, and materials* drive changes in the consumption and use-patterns of everyday life. Both frameworks recognize that the critical infrastructure of creativity, diversity, and coherence is driven by the ongoing churn between people's thoughts, practices, and the materiality of our environment.

The Suggested Actions are in no particular order.[1]

People

People are agents of change for sustainable communities and economic development, and they are intermediaries for learning and innovation. Group dynamics are as important as individual characteristics. Human communication processes that help to uncover shared goals and perspectives assist in creating cooperation. Political dissonance, power dynamics, and social relationships underscore the diversity paradox, according to which the costs of cross-disciplinary coordination increase with the size, diversity, and complexity of a community.

This section suggests actions that impact people and their ability to work cooperatively toward shared objectives. This includes the skills and qualities of people engaged in cross-disciplinary work; how people are appreciated, valued, and engaged as members of organizations; and how organizational design influences the impact of learning and innovation on society.

Research behavior and skills in cross-domain research and creative work
Suggested Action: Develop insights around the skills and competencies of practitioners in diverse disciplines and around how those behaviors are manifested in collaborative research, and how they can be improved.

New skills are constantly emerging, and old and existing skills are being reapplied to new tasks. Because knowledge, research, and organizations change, the kinds of skills we value are constantly in flux. Students and practitioners should be able to identify and communicate skills. They should also be able to assemble skills and goals into stable, long-term career trajectories within and across disciplines. But to do that, they need better resources for learning how skills translate across domains.

Being able to identify and communicate skills and their value is an emerging social and technical challenge in the era of big data and deinstitutionalized labor markets. Communicating skills reduces friction in job markets, and it improves face-to-face and virtual group collaboration through better understanding of individual roles and abilities, resulting in many positive psychological benefits.

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1 Questions and comments about this analysis should be directed to gabrielharp@gmail.com.

In order to increase engagement and create new attractors for connected learning, skills and competency clusters can be recast in compelling language and representation.

Incorporate conflicting values by reframing research and creative work objectives
Suggested Action: Identify and develop frameworks for research and creative work that help to clarify objectives, communicate scope, and incorporate conflicting values. Using case studies and process-based steps, build links to larger societal concerns as well as incentives for participation around those concerns.

Diverse teams often experience higher coordination costs than homogeneous ones, and research objectives and contexts may need to be actively reframed to align values and provide clear goals for participants and stakeholders. Active and iterative research framing is a participatory research process, and it develops from explicit discussions of goals, assumptions, and processes.

The two-cultures debate has not yet developed a productive research agenda. Instead we could look toward the periphery, where the future of cross-domain work involves diverse institutions, projects, and individuals who can find their own alignments to work from instead of overly simple art/science or academia/industry bifurcations.

As a society we are quickly scaling up our ability to observe unseen processes from beyond our human observer status, and our capacity for doing so is expanding toward larger, more complex forms of organization. We are critically short on the tools, practices, and training needed for working collaboratively with diverse teams on ill-defined problems.

A "moonshot" goal of dampening climate change-related behavior is a good example of how to enable active research, define common pathways for success, create identifiable communities, and condense clusters of activity. For one thing, it creates a common "North Star" for people to identify and orient their activities. In addition, many tiny research experiments with well-defined commonalities would create "scattershot" solutions to simpler problems and provide short-term successes to build on, out of which would emerge case studies to demonstrate the efficacy of different approaches. Longer-term research agendas with detailed approaches and degrees of complexity could build on these communities and small solutions.

One important obstacle needs to be considered. Practitioners in the sciences, arts, and other domains can often rely on values that incorporate moral beliefs and drive action in ways dissociated from their prospects for success. These are called sacred values, and they arise from metaphysical commitments and expectations about culture. Sacred values can complicate

people's assumptions about who and what counts as evidence, how research can and should be communicated, or about the role of individual subjectiveness in self-expression. In the past, statements like "Science is objective," "Designers don't belong in hospitals," or "Artists should be able to say or do whatever they want" demonstrate deeply held commitments. Because these values tend to emerge in cross-domain work, they should be identified as such and actively understood by participants to reveal their full intent and meaning.

Reframing scared values can open up new pathways for participation and advocacy in research, and this comes from understanding researcher's needs as well as new interpretations of the research questions. Because sacred values can reveal intense social conflicts, they often form the vanguard of broader societal concerns.

Understanding and having a plan for working through sacred values in cross-domain research enables better translations of research insight and technologies into everyday social practice.

Extend project-based curriculums to develop cooperation, coordination, communication, and collaboration skills
Suggested Action: Develop project-based curriculums and programs that build skills for cooperation, coordination, communication, and collaboration across a variety of cross-disciplinary and creative research contexts with varying levels of goal-orientation and problem fuzziness.

One of the biggest impediments to learning and change in cross-disciplinary research is recognizing the important differences that people bring to common goals and how those differences positively impact creative work.

Teamwork, meanwhile, is not merely cooperative but highly coordinated, with special communication and cognitive skills. It requires intimate acquaintance with each other's knowledge, motivations, physical capabilities, the ability to respond instantly and together, solutions for reevaluating on the fly in the face of sudden situational changes, unexpected threats, and each others' unforeseen failures and successes; it also involves clear signaling to one another what course of actions to take (Atran 2010, 314).

Describe new and emerging skills in compelling language and representation
Suggested Action: Identify new and emerging skills and describe them in compelling language and representation.

New and Emerging Skills Attractors

Reframing and re-creating new skills descriptions that positively reinforce our goals and people roles in society can be a good way to redefine what it means to do creative work and research. A "firstarter" is the ability to take an idea and influence others in a group to adopt and act on it. A "longbroader" is someone who can think and act on a much bigger picture—thinking in terms of multiple systems, bigger networks, and longer cycles. "Emergensight" is the ability to prepare for and handle surprising results and complexity that come with coordination, cooperation, and collaboration on extreme scales. What are the cross-disciplinary work and creative research skills that will drive economic growth and community stability in the future? What are the words and terms we will use to describe the kind of work we do in the future?

Disseminate best practices as toolkits for pop-up, locally produced initiatives
Suggested Action: Create sets of best practices that can serve as toolkits and starting points for new groups attempting to undertake new endeavors.

One of the most successful outcomes from any organization or initiative is when others can learn from successes, failures, and practices that were used. Toolkits that provide ready-made templates, descriptions of processes, or plug-in activities and methods create a starting point for others to follow. This lets new projects decide what is important about their local needs without reinventing the wheel for each and every endeavor.

Identify and create new business models, resources, and mechanisms of support
Suggested Action: Identify sustainable modes of support, resources, business models, and funding that will serve as durable engines of growth.

Economic growth is remarkably agile, and some anticipate that the real economic growth will not come from saving labor but in creating new kinds of things to do. Greater degrees of playing, creating, and exploring are only constrained by the boundaries and priorities we set.

Emphasize entrepreneurship skills, negotiation strategies, and metacognition-based competencies
Suggested Action: Provide access to developmental tools, training, and resources for building broad competencies in entrepreneurship, negotiation, and metacognition.

Entrepreneurship Unbound
A broad base of entrepreneurial skills is necessary to participate in the new economy. Training in business tools and skills—including finance, operations, marketing, and negotiating—are

critical, even if not used for the purposes of business. Emerging work practices span long distances, involve deep collaboration, and are often not connected to large organizations as the primary source of employment. As the friction in employment markets decreases and people with the right skills are more easily accessed, the ability to form groups and manage one's own employment trajectory is becoming increasing more important. And by combining entrepreneurial training more openly with other forms of training, it is also likely that many new forms of financial, marketing, operational, and negotiation strategies will emerge, enabling innovation beyond the confines of the business class.

Negotiation and Influence
Interpersonal and technology-mediated cooperation skills need to be more actively developed and built into the curriculum. Because globalization and interdisciplinary work are expanding rapidly, negotiation skills are perhaps the most valuable tools that students and professionals can acquire in the next two decades. These metacognition skills help us think about how we think and focus attention on how we operate in diverse groups and in contexts with shifting priorities. Broadening the base of these so-called soft skills for research and creative professionals will enable better forms of cooperation and more positive influence from creative practitioners across organizations. This comes at a critical time when the ability to influence and define what matters in an increasingly noisy environment pays dividends in our capacity to respond to global challenges.

Use insights from social studies of science and technology as a bridge
Suggested Action: Develop applied programs and projects that translate insights from social studies of science and technology to creative practice in the context of science, engineering, and other domains.

The field of science and technology studies (STS) is an important disciplinary link for cross-domain work between art, design, science, and engineering. By observing and reporting on the social activities of different disciplines, STS can identify common research currents and future pathways for mutually reinforced agendas. It is precisely because STS includes both human and non-human entities and processes that it can work as an arbiter and bridge between disciplines, fostering creative outcomes.

In *Leviathan and the Air Pump* (1989), Steven Shapin and Simon Schaffer describe three types of public witnessing of science: the direct performance of experiments in social spaces, reporting experimental methods in a manner that enables someone to replicate the experiments themselves, and virtual witnessing by producing in a reader's mind an image of an experimental scene that

displaces the need for direct witness or replication. Each of these three types of witnessing provides an example of a pathway for cross-disciplinary work.

Other mediation activities, such as those described by Callon (1986) and Lee and Roth (2001), translate research across social and physical domains for the purpose of proposing, deciding upon, and implementing preferred design actions. Funtowicz and Ravetz (1991) describe a post-normal science framework as a bridge between complex systems and environmental policy, while Frame and Brown (2008) go further to identify specific post-normal technologies for organizing cross-domain creative work.

Spanning social gaps and assembling diverse constituencies is a feature of innovation, and Burt (2000) proposed the term "network entrepreneur" to describe and quantify a kind of persona and the role it plays in organizations. Burt's description formalizes Fuller's (1963) description of the Comprehensive Designer, which Turner (2008) expanded with a profile on Stuart Brand in a book that looked at how art, technology, and entrepreneurialism developed into contemporary digital utopianism—a general feature of today's technology and economic landscape.

STS can also offer cross-cutting ways to rework cross-disciplinary relationships. Steven Jackson (forthcoming) discusses how a recentering of maintenance and repair may help with the necessary project of building bridges to new and adjacent fields including material studies, craft, technology for development, sustainability studies, and new media. In Jackson's words, "It may also help build new analytic connections to cultural phenomena—maker and DIY communities, craft and slow food movements, and cultural forms from fan fiction to the Steampunk movement—that feature breaking, maintenance, and repair as central sites of activity and meaning."

Show applicability of skills and behaviors across domains while reinforcing domain-specific expertise
Suggested Action: Develop shared knowledge and understanding of how skills are realized (along with trade-offs) across different sectors in industry, academia, and civil society.

One of the biggest impediments to learning and change in cross-disciplinary research is recognizing the important differences that people bring to common goals and how those differences positively impact creative work. There has been a long and intense effort for domains such as science, art, design, and engineering to develop skills valuable for work. There has been less attention focused on how those skills can translate to and become valuable for other, unintended domains. This means expanding the definition of expertise to include the ability to

understand when naive others are trying to communicate, verifying it, and offering assistance with the language tools to express it.

Survey organizations and initiatives to identify best practices, insights, and organizational tactics

Suggested Action: Canvas organizations, initiatives, networks, institutions, events, and activities for best practices, insights, organizational tactics, and missions using a common survey.

Cross-domain research and creative work are already practiced, but instances are unevenly distributed across domains, institutions, and geographies. A wide variety of institutions and organizations are helping to create platforms for research and creative work, but many of these activities do not fit into the canons of established domains. An important task is to identify the kinds of partnerships and organizational designs that are successful and to clearly share those strategies and models more broadly.

Hack weekends and festivals provide event-driven context and momentum for creative work; they also help people find others who have shared interests and complementary capabilities. Regional cultural organizations like the Grey Area Foundation for the Arts (GAFTA; http://www.gaffta.org/) provide courses on new technologies, art and hacking weekends, and festivals that explore emerging areas. GAFTA recently held the first Urban Prototyping festival, providing a forum for projects and discussions to explore how technology experimentation and urban infrastructure are creating new paths for economic development and community sustainability in cities.

Science Hack Day (http://sciencehackday.com/) is an event series that brings designers, scientists, engineers, artists, and others together to collaborate on focused tasks during this short period, building on the premise that small groups of hackers are capable of producing remarkable results. Science Hack Day demonstrates an important design consideration for cross-disciplinary work. Collaboration on focused tasks is essential for participant experience; it takes consideration and effort to develop and implement the social infrastructure for collaboration and focus.

Other organizations like TechShop (http://www.techshop.ws/) are more agonistic in their approach, providing high-quality tools and workspaces for collaborating and creating prototypes and products. There are no restrictions on membership except for a monthly fee, and it's a common occurrence for nascent start-ups to use TechShop as their hub and workspace. Similarly, hacker spaces like Noisebridge (https://noisebridge.net/wiki/Noisebridge)

maintain an open, free space for hackers, makers, and creators of all kinds, including journalists, apps developers, biology researchers, and educators, who can find tools, connect with different communities, and have a place to call home. One important feature of emerging spaces like these is their tendency to experiment with different forms of organizational governance. While TechShop simply charges a fee to maintain and provide resources with relatively little role for members in governance, Noisebridge has open governance, placing more responsibility for maintenance on members and participants.

The MIT Media Lab (http://www.media.mit.edu/)is a well-know example of how a institution can create a long-lasting impact and provide training opportunities, entrepreneurial partnerships, and global influence. Smaller sites, like the GROCS Lab (http://www.dc.umich.edu/dl1/) at the University of Michigan, have seeded small working groups to define and assemble innovative projects, although more entrepreneurial assistance is often needed to help small groups achieve larger impact. Many investment firms have long recognized this need; firms like Innovation Endeavors (http://innovationendeavors.com/) provide support in areas ranging from strategy to operations and offer community development through hackathons, brainstorming sessions, and block parties.

Initiatives such as the Creators Project (http://thecreatorsproject.com/), a partnership between Intel and Vice, were created to elevate the impact of art and technology in the media, supporting media artists, scientists, and entrepreneurs of all kinds. In the Creators Project example, there is mutual interest at work. Vice, a media company, aims to catalyze the development of new content. Intel, a microchip manufacturer, aims to understand examples of emerging uses and develop microchips that will support future computing needs. By partnering as the Creators Project, they empower others to actively make the future, providing Intel and Vice better proximity to emerging use cases, talent, and technology.

Amplify and validate strengths-based learning of unique skills and collaboration tactics
Suggested Action: Create strengths-based learning about skills across domains. Help students and practitioners concretely describe and validate their self-reported strengths and skills and match them to those of others for collaborative endeavors and teams.

The task of research and creative work requires collaboration. In a report conducted on behalf of Google, The Future Foundation (2010, http://goo.gl/zjnGny) found an 81 percent correlation between collaboration and innovation based on respondent self-reporting and agreement in a survey of 3,500 employees, 100 HR managers and 100 IT managers across the United Kingdom, France, Germany, the United States, and Japan.

In the "IBM Global CEO Study 2006," 75 percent of respondents ranked collaboration as a "very important" part of innovation—and of business success in general (http://www-935.ibm.com/services/us/gbs/bus/pdf/ceostudy.pdf). The study found that extensive collaborators tended to outperform their peers in key business performance indicators such as revenue growth and operating margins. What's more, companies collaborating with external sources reported higher revenue growth, on the whole, than companies not collaborating with external parties.

One of the most compelling strengths-based training platforms was a free, open, social network game (http://www.urgentevoke.org) whose goal was to help develop skills that would empower people all over the world to come up with creative solutions to our most urgent social problems.

PRACTICES

Practices are the behaviors that people utilize in everyday life to achieve their goals. People find ways to cooperate and dissent, frameworks to think and act through, and rubrics to structure their assessments of others. Rules and social norms pattern our practices, and these practices may develop along explicit or implicit disciplinary boundaries.

This section suggests actions to help us understand and develop practices that result in better forms of learning, innovation, sustainability, and development. It identifies domains and strategies for communication, collaboration, coordination, and cooperation, and it marks pathways for creating, acquiring, and normalizing infrastructure to support these practices.

Promote and install projects that build and contribute to creativity research
Suggested Action: Promote and install projects that build and contribute to creativity research.

Combinatorial theories about innovation and creativity describe how entrepreneurs and researchers remix various parts to create better solutions. Getting more of those parts, whether they are Legos, genes, concepts, screwdrivers, paintbrushes, or peaches, on the table for diverse cross-disciplinary research and creative work is a key to the next generation of the creative economy. Most of those combinations will fail, but there will also be massive successes. Right now the bits and objects of software are driving the latest combinatorial explosion, much like reproducible parts did for manufacturing. Soon, reconfigurable genetic material, financial tools, governing resources, and communication techniques will drive another wave of technological and social change.

Develop reciprocity-based research procedures and outcomes
Suggested Action: In order to facilitate broader social engagement for creative work and cross-disciplinary research, identify and develop new opportunities for public engagement, participation, and reciprocity-based outcomes.

Creative work and cross-disciplinary research that fosters engagement, participation, and reciprocity creates a broader base of support, with more durable communities and resources for economic growth emerging as a result.

Participation increases in intensity from information extraction, to feedback of information, implementation, goal setting, ownership, and ultimately to influence and migration beyond the original initiative or community.

Projects and policies that enable reciprocity and provide mechanisms for participants to realize mutually beneficial outcomes for themselves and others are more willing and able to create, own, and disseminate the products of creative work and cross-domain research. That is, if people can have a stake in the results, they are more likely to engage with it, add their talents and skills, and broaden its impacts across diverse communities.

Develop art and design-based practices for conceptual change management and innovation in science and technology
Suggested Action: Develop a comprehensive art and design-based practice for conceptual change management and innovation in science and technology.

The outcome of enhanced participation is new avenues for conceptual change. People who are engaged in a participatory way tend to modify their existing beliefs more readily. They have to justify their assumptions and attend to the differences shared by others, and this can reshape the scope and direction of creative research and its results.

A program that situates art and design as interlocutors of conceptual change in science and technology can result in research that highlights innovation tools and strategies.

Assemble collaboratively produced, cross-disciplinary cartographies of science and technology issues using controversies as a lens
Suggested Action: Controversies in science, technology, and public policy provide a useful lens for unraveling the concerns and interactions of scientists, researchers, creators, and their tools.

The Mapping Controversies curriculum (Venturini, 2009, 2012) *provides a practice-based collaborative approach for journalists, scientists, technologists, designers, and cartographers to examine creativity and community stability in socio-technological dynamics.*

Technological development creates new controversies in society. Although many cross-disciplinary research activities are ad hoc, some methodologies are being developed as pedagogical tools for training students in the collaborative tasks and skills to explore, visualize, and engage with emerging technoscientific issues. One of these methodologies is the cartography of controversies, and it assembles tools and research practices to explore the relationships across democracy, science, technology, design, subjectiveness, innovation, and social change (http://www.demoscience.org/)

The cartography of controversies aims to develop the skills of researchers working together in diverse roles ranging from research scientist, journalist, information designer, and cartographer. The goal of this pedagogy is to demonstrate how people, platforms, and practices create new knowledge and how social and political choices impact creativity and innovation opportunities for research and discovery. The broader impacts of this kind of work are that it provides an extensible platform for public engagement with (though not exclusively limited to) technoscientific issues—while fostering the participation of designers, artists, journalists, and others in the documentation process.

Develop SEAD/NSF as a platform for peer-to-peer connectivity and networking between researchers
Suggested Action: Provide networking tools for collaboration with both funded and unfunded researchers. Develop SEAD and/or the NSF as a platform for peer-review, peer-to-peer connectivity, and networking.

The National Science Foundation has a unique hub-like position between many researchers, policy makers, institutions, and endeavors. It can play a more active role in building cross-disciplinary research and creative work simply by making the activities of those with whom it engages more visible to others in the network.

SEAD can extend this visibility among stakeholders. Where size and institutional constraint delay action from the NSF, SEAD can act as a bridging organization, connecting like-minded individuals and research endeavors while brokering discourse, funding, and diverse communities of practice. SEAD can engage more directly with departments, schools, societies, individuals, vendors, and policy makers to organize an emerging research agenda.

Employ visual and analytic tools to explore the edges of cross-domain research and creative work

Suggested Action: Employ tools and people and projects that search for and uncover processes, practices, and paradigm shifts at the edges of cross-domain research and work using aggregated data sources. Use these economic insights and relationships as leverage points for understanding networks of cross-disciplinary research and creative work.

Meta-perspectives based on images and insights from whole research domains and patterns of economic exchange can be used to glean new practices and procedures in developing fields. Meta views compiled from content analyses provide maps of information flow and can reveal community structure in complex networks (Rosvall and Bergstrom 2007). These new "macroscopes" help describe the changing landscape of science and show transitions from stars to teams, users to contributors, disciplinary to cross-disciplinary, specimens to data streams, and from instruments to cyberinfrastructures (Börner 2011).

Movement, communication, and activity patterns can inform design and the development of infrastructure (Jiang et al. 2012), the role of media in the adoption of innovations (Jameson, 2012), creativity and problem-solving in groups (Kidane and Gloor 2007), the relationship between personality and social networks (Hildago 2011), and gaps and opportunities for economic development (Hildago et al. 2007).

Many data sources abound, including a trending Twitter hashtag called #overlyhonestmethods that was started to explore the diversity of human practices underlying the scientific method. Part tongue-in-cheek humor and part open confession, each post in the stream captured examples and stories about how research was conducted—stories and examples unlikely to make it into published research accounts but nonetheless serve as examples of norms and creativity among research practices.

Data-driven meta-analyses provide useful insights about gaps, relationships, temporal patterns, and activities that can be used to focus questions around cross-disciplinary research and creative work. Insights, analytics, and first-hand observations enable comparative approaches and can help justify research objectives.

Identify the impacts and emerging skills of social production for cross-disciplinary and creative work
Suggested Action: Identify new and emerging forms of social production (from citizen science to task routing and DIY) and explore how they will create broader impacts—including the skills that will be needed to engage across disciplines and creative modes.

Social production describes a model of socioeconomic production in which the creative energy of large numbers of people is coordinated (often with the aid of the Internet) into meaningful projects, mostly without traditional organizational hierarchy. Forms of social production include crowdsourcing, peer review, open innovation, open source, formal and informal education, co-creation, citizen science, collaboration, and crowd financing—among many others.

Social production is shifting the benefits that many organizations provide, destabilizing many traditional forms of work and organization in the process. Science, engineering, art, and design will all be affected. Issues, skills, impacts, and best practices can already be identified and used as catalysts for cross-disciplinary and creative work.

Encourage and support communities of practice and bridging organizations
Suggested Action: Create, curate, develop, and maintain focused communities of practice around core themes, concerns, and topics.

Digital humanities has emerged as a field over the last decade, driven by the emergence of new digital tools for communicating and for processing information from online social media collaboration to data illustration. The Humanities, Arts, Sciences, and Technology Advanced Collaboratory (HASTAC; http://hastac.org/) has led by example with platforms, conferences, competitions, courses, and best practices. Among the many outcomes, peer-grading and badges have garnered significant attention in recent years as ways to make teaching and learning more participatory while providing new tools for people to transfer their expertise to other domains. HASTAC administers the MacArthur Foundation's Digital Media and Learning Competition and works in collaboration with Mozilla and other organizations, as well as internationally with many universities and schools. By assembling a mix of talent, platforms, best practices, scholarship, funding, and cross-institutional networking, HASTAC not only supports the development of an emerging field, but it has helped launch new creative endeavors and research questions along the way. Significant is the role that HASTAC plays as a bridging organization between the foundation, universities, community schools, and research communities.

Support open-source innovation, skills, and practices around the "Internet-of-things"
Suggested Action: Support open-source innovation around the Internet-of-things, including the development of skills and practices.

An Internet of things is being built by connecting many different kinds of objects, sensors, actuators, people, and other organisms to the Internet. Cars, cameras, coffee machines, and even Band-aids are becoming networked technologies, and this means that the practices and products of science, design, engineering, and art are poised to undergo a massive transformation. New practices will emerge to monitor, track, and develop new constellations of toolsets and services. Organisms and phenomena will have additional "voices," making design for meaning a critical skill. The era of big data made possible through low-cost sensing, storage, and networking is also making it more critical for people to develop the skills needed to manage a wider array of information and meaning.

Make all NSF-supported research open-source and accessible to the general public
Suggested Action: Make all NSF-supported research open-source and accessible to the general public.

Research products, including data, reports, tools, and software, should have some minimally viable presence as a resource for the public to access and learn from–independent of institutional affiliation or sponsorship.

PLATFORMS

Platforms are physical or social tools, environments, and enabling resources that let people communicate, collaborate, coordinate, and cooperate effectively. Specifically, we can define a platform as a form of infrastructure that increases the likelihood of improved learning, innovation, community sustainability, and/or economic development. As a consequence, platforms should reduce barriers to participation and action.

An analogy for platforms is that they lower the "activation energy" or the amount of work needed to perform a task. By scaffolding different forms of support, platforms may reduce transaction costs, aid in memory recall, or script people's behavior in a specific way that leaves time and attention available for more creative activities. For example, WordPress is a platform for writing blog posts without much coding. A bed is a platform for better sleeping. A grading rubric is a platform for assessing objectives and achievements.
http://www.mitpressjournals.org/doi/abs/10.1162/desi.2007.23.2.3

This section suggests actions to support the development of platforms that lower the burden of cross-disciplinary research and creative work. Successful platforms often maintain multiple, diverse forms of support, and not all platforms are designed.

Activate experimental infrastructure and event-driven architecture
Suggested Action: Develop insights, best practices, and incentives for experimenting with the architecture and the collaborative spaces of research and creativity.

The spaces, architectures, and infrastructures that different communities use to carry out their work may need radical transformation, or they may simply need a nudge. Different kinds of spaces support different kinds of interactions, but opening spaces up to the possibility of experimentation may be enough to foster knowledge transfer, information exchange, and/or focus. Examples of abound in news articles and the literature, while the legendary status of spaces like Building 20 at MIT provide ready-made examples of how architecture and knowledge-spillover are tightly linked.

The Stanford d.school is a cross-domain program that provides courses and research opportunities for students from all of Stanford's departments. As a result of having moved multiple times in its short history, the program captured the knowledge of how it used different spaces to support different kinds of interactions and has provided those insights in the form of a manual (Doorley and Witthoft, 2012).

Furniture companies like Herman Miller and Steelcase regularly capture insights around the relationships among space, architecture and collaboration, and they fold them into their design process. Not all solutions work all of the time, but the solutions provide new models to try in new contexts for diverse users, along with the license to try new configurations. It's also critical that assumptions about those spaces are shared with the community—in case the community feels differently.

One of the most important areas of research in the next decade will be the relationship between information and architecture, where knowledge spillover carries long distances and the Internet is no longer confined to a screen.

Sustainability through new forms of community-based financing, bridging organizations, co-production, and transparency
Suggested Action: Experiment with and develop new forms of community-based financing, bridging organizations, co-produced research, and tools for organizational transparency.

Deinstitutionalized infrastructures utilize crowdsourcing, crowdfunding, bridging organizations, and other forms of transparency to decrease the barriers to accomplishment and increase people's engagement around the problems they are trying to solve—from research to implementation. However, the result is not necessarily a reduction in hierarchy and accountability. Rather, resources and tools that increase feedback and accountability can help increase institutional responsiveness and the ability of any one individual or group to make positive change and impact.

Extend sustainability-based values, accounting transparency, and budgeting standards deep into the research supply chain
Suggested Action: Require accounting transparency and budgeting standards that extend sustainability-based values deep into the supply chain.

Deinstitutionalized infrastructures that utilize crowdsourcing, crowdfunding, bridging organizations, and other forms of transparency can decrease the barriers to accomplishment and increase people's engagement around the problems they are trying to solve.

However, new tools and information practices are needed to surface increasingly hidden accounting practices and inhibit feedback and accountability. Feedback and accountability are critical for institutional responsiveness and the ability of any one individual or group to make creative positive change and cross-disciplinary impacts for community sustainability and economic growth.

Hybridize virtual and physical learning and research mash-ups
Suggested Action: Create hybrid learning and research mash-ups that expose teachers and learners to multiple forms of content, engagement, and goals, both online and off.

Innovations in education, ranging from Massive Open Online Courses to video games, are rapidly becoming learning platforms that can scale teaching and instruction using the Web, videos, assignments, activities, discussion forums, and other forms of engagement.

While a great deal of attention has been given to massive online classrooms and these other new forms of learning platforms, their most important feature is their ability to provide resources and memorable learning experiences.

Therefore, hybrid learning and research mash-ups that utilize blended environments and both physical and virtual tasks can expose teachers and learners to multiple forms of content, engagement, communities, and goals.

Create comprehensive training grants around new and emerging themes

Suggested Action: Create comprehensive training grants for researchers and students around new and emerging themes.

Training grants such as NSF's IGERT program and cross-disciplinary synthesis centers can facilitate the research improvement, international engagement, and other broad impacts with support for residencies, workshops, and meetings. The National Evolutionary Synthesis Center, for example, hosts a variety of researchers who contribute to efforts that integrate knowledge within the field of evolutionary biology and systematics.

Residency programs in specialized disciplines can creatively reinforce their own mission and impacts by inviting cross-cutting proposals for residencies and activities from other domains. It is essential that calls for proposals and participation include an explicit invitation to a wide array of creative applicants. Otherwise, self-selection often eliminate potential applicants.

Redefine participation criteria

Suggested Action: Redefine the criteria for participation and broaden access beyond traditional institutional boundaries and definitions. Create new pathways for PhD and non-PhD researchers and PIs. Facilitate innovative funding models and support for international engagements.

Building parity is critical, but it doesn't only have to happen through traditional methods like compensation or degrees. Creative solutions can increase parity and the prospects for cross-domain collaboration using a variety of incentives, boundaries, resources, and outcomes. The PhD, institutional incentives, and tenure are significant negotiating points for the future of cross-domain work in the academy. Mechanisms that level the field of partnerships, provide better incentives for longer-term thinking, collaboration, and genuinely creative outcomes. Institutional affiliation and principal investigator designation may be one pathway for extending an individual's ability to create, assemble, and implement promising research.

Innovate around proposal requirements, submittal, and peer evaluation of research

Suggested Action: Innovate around the peer-review process and proposal requirements, submittal, and evaluation.

Grant-based funding often resembles a competition, and this can be experimented with as an institutional mechanism for evaluating proposals and/or for supporting creative work. Competition can be generative, and it does not always have to be a winner-take-all affair.

Although there are many reasons to believe that competitions favor diversity, they can also serve to hide institutional biases towards established players and solutions, limiting the value and frequency of innovative work. Many small experimental funding and proposal mechanisms may uncover new sources of creativity and diversity that tap diverse actors and less common solutions.

Incentivize professional organizations as catalysts for change
Suggested Action: Professional organizations can play a more supportive role as catalysts for change, harbingers of skills and emerging behaviors, and cross-disciplinary relationship building. They should be incentivized to do so.

Strong, supportive, and value-driven professional organizations need to identify and develop the unique capacities of their members, especially where formal institutions are unable to. They can do this by providing assessments that demonstrate the social benefits that their constituency brings to society, models for best practices, developmental opportunities for skills, cross-functional relationship building, and objective standards for decision making around jobs, grants, and other forms of negotiation. Professional organizations can serve emerging and/or established constituencies by developing mutual understanding of the strengths that people bring to teams and new endeavors. Professional organizations can also take the lead as a bridging organization for themes of critical interest.

Integrate design thinking into the scientific method and other forms of creative research
Suggested Action: Develop and integrate design thinking into the scientific method. Extend cross-disciplinary collaboration from individuals and groups to entire organizations and inter-organizational challenges.

"Design thinking" is the term used to describe how people can share ideas from across different perspectives and iteratively add new insights to create and define something that a single individual could not have developed on his or her own. One of the major reasons for the success of design thinking is that it often takes group dynamics into account and relieves some of the social costs of brainstorming. Design thinking can encompass a variety of stable, standardized techniques to encourage creative thinking and collaboration while minimizing the common pitfalls of group-based collaboration. Design thinking has even been codified into online

platforms (http://www.hcdconnect.org, http://www.openideo.org) for designing solutions to difficult problems like education, nutrition, and sanitation.

Support inter-operable tools and Advanced Programming Interfaces (APIs) that can bridge people, machines, artifacts, and non-humans
Suggested Action: Fund and support human/object/machine/nonhuman interoperable tools and APIs for science, engineering, and creative research.

Interoperable interfaces and tools can help lower the learning curve of complicated technologies and cyber-infrastructures. Tools and APIs that connect people to people, machines to people, objects and tools to machines, nonhumans to people, and more provide a basic infrastructure for cross-functional research and new creative uses of technologies. By offering advanced scientific, artistic, design, and engineering capabilities (such as shared time on supercomputers, telescopes, or sequencers) at a lower cost (from the increased scale of use), new creative work activities may result in transformative research outcomes.

Encourage institutional "plug-ins" to provide access and lower transaction costs
Suggested Action: Provide plug-in opportunities for organizational and institutional access emphasizing low transaction costs, ease of movement, and support for basic creative research needs.

Organizations are starting to understand the value of open-source innovation and creativity, and as a result they are starting to develop platforms for people and processes to plug into their internal work. These organizational plug-ins may extend collaboration and institutional capacity by allowing outside researchers greater levels of engagement with an organization, along with the rewards of increased access to internal knowledge resources. Or it may entail the measured release of research products, from data to tools. Many organizations are finding that in order to innovate across disciplines and produce creative work, they must share their knowledge and resources, even with their enemies. Cooperation is the new competition.

Mozilla, the nonprofit that produces the Firefox browser and operating systems, has recently started providing gateways for participants from outside of the organization to access contacts with people, internal data, and services. The Mozillians' API is a vouched-status key that allows people who have demonstrated their trustworthiness access to different layers of the organization.

Amazon has built its entire cloud-service business model on the basis of designing all of its service interfaces to be externalizable from the ground up. The company designs its entire technology base for the purpose of exposing it to developers in the outside world.
Many models for this kind of institutional access exist, from courtesy and affiliate faculty appointments to guest library and computing accounts. By creating new forms and capabilities for people to access and interface across institutions and boundaries, institutional gateways like these reduce obstacles for collaboration and communication, providing better resources for creativity and innovation.

Spread awareness of inter-operability benefits and flexible standards
Suggested Action: Spread awareness about the benefits and values of interoperability and standards-based flexibility in technology development. Create incentives for building linkages between locked-in systems.

Gateways are simple platforms that help connect different perspectives, institutional processes, and technologies. They are a lot like the travel adapter we use when traveling abroad to connect a plug to a local outlet. Gateways provide additional flexibility, interoperability, and compatibility between diverse sub-systems.

APIs are a common example of how gateway technologies can be used to create cross-compatibility between different software services. Typically, an API lets a service (like Google Maps, Facebook, or Twitter) publicly expose some of its data or functionality to outside developers who then use "hooks" to call those resources and apply them creatively to another service. This open architecture facilitates a rapid increase in the ways that services and resources can be recombined. Companies like If This Then That have even sprung up around APIs and are developing simple tools that let anyone connect different services together in useful and creative ways.

An artifact-based example of a technology gateway is The Free Universal Construction Kit, which provides adapter pieces that fit different types of toy building systems—from legos to tinker toys—together. Gateways technologies are thus meant to create a common link between two or more standardized systems, expanding the flexibility inherent in those systems. Similar kinds of interfaces are now being developed to provide gateways for molecular systems in synthetic biology (e.g., Biobricks) and across design tools and living systems (Autodesk Research). Creating tools that help users connect different resources and objects can augment existing forms of innovation, cross-domain work, and creative research.

Gateway technologies and other forms or adapters that provide interoperability are reasonably well understood in technological contexts, and they are valuable because they operate below the level of the actual work, making them invisible for the most part. However, gateways can be used to create cognitive or interinstitutional linkages as well.

Gateways don't always have to be based on objects or tools, per se. Cognitive gateways enhance shared understanding, cooperation, and creativity. Brainstorming is one widely used gateway platform for ideation. Often, the simple acts of restraining judgment or making ideas visible for others to see can help connect people's divergent assumptions and interpretations. In this way, people and their perspectives are the subsystems being connected by a social gateways technology, namely, cognitive coupling.

Incorporate foresight perspectives into cross-disciplinary work and creative research
Suggested Action: Incorporate forward-looking perspectives into cross-disciplinary work and creative research.

Foresight involves critical thinking about long-term developments, debate and effort toward wider participatory democracy, and tactical media aimed at shaping the future, especially by influencing public policy.

Artifacts of the future and design fiction are examples of how foresight—embodied as objects, products, or services—can portray a version for how different actors and community needs will align in the future. Artifacts of the future provide a tangible experience of the future and the benefit that, as community stakeholders weigh in, they are anchored by the concrete representations of the artifact. This helps scaffold their long-term thinking around entities and processes.

Build communities of practice around boundary objects with specific goals and objectives
Suggested Action: Build communities of practice around boundary objects with specific goals and objectives.

One of the ways that heterogeneous, cross-domain cooperation and creative work has been able to incorporate multiple goals and perspectives is through the use of boundary objects. "Boundary objects" describe the social function of objects and artifacts that emerge and exist at the intersections of multiple communities and manage emerging tensions (Star and Griesemer, 1987).

Boundary objects can be repositories for knowledge such as databases, cabinets of curiosity or natural history collections; ideal types like diagrams, flags, or even stems cells; artifacts with coincident boundaries like maps or metaphors; or standardized forms for common communication like jargon or species designations. These objects are plastic enough to respond to local needs, but they are also static enough to carry meaning across many locations. They satisfy the informational and evidential needs of different communities while supporting certain forms of work and extending to others.

Boundary object-based research endeavors would help link past practices to future work goals with defined objectives (e.g., how to integrate underrepresented communities). Often this work involves creating alignments between political, economic, social, technological, and ecological goals. Because boundary objects are objects, they are highly amenable to creative work from product designers, interaction artists, performance artists, architects, and many others.

Clarify, diversify, and incentivize NSF broader impact requirements
Suggested Action: Clarify and diversify the broader impact requirements for grantees. Reward innovative broader impact proposals disproportionately.

Broader impact statements are required by all NSF proposals, and, in addition to demonstrating technical merit, they can be a significant and powerful place for cross-disciplinary research and creative work to demonstrate its value. More effort and attention should be directed at identifying concrete objectives and impacts for cross-domain research and creative work. Solutions for creating broader impacts, and appropriate rewards for those proposals that do, can call attention to and reinforce the societal benefits they offer, providing a goal-driven mechanism to communicate the benefit of research to society.

Helga Nowotny, president of the European Research Council, has, with others, been arguing for the development of "socially robust science" (Nowotny, 2003; Gibbons, 1999) Broader impact requirements could be developed for projects that include professionals from the arts, design, and humanities within scientific project teams to articulate and address interest. Scientists usually feel that peer review by scientists is sufficient, but there is a growing argument that science needs to open new peer review systems that include people outside the specific discipline.

Bibliography

Atran, S. 2010. *Talking to the Enemy: Faith, Brotherhood, and the (Un)Making of Terrorists*. New York: HarperCollins.

Börner, Katy. 2011. "Plug-and-Play Macroscopes." *Communications of the ACM* 54 (3): 60-69.

Burt, R. S. 2004. "Structural Holes and Good Ideas." *American Journal of Sociology* 110 (2): 349-99.

Callon, M. 1986. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay". In John Law, ed., *Power, Action, and Belief: A New Sociology of Knowledge?* Sociological Review Monograph 32. Keele, UK: University of Keele.

Doorley, S., Witthoft, S., & University, H. P. I. of D. at S. 2012. *Make Space: How to Set the Stage for Creative Collaboration* (1st ed.). Wiley.

Frame, B. and Brown, J. 2008. Developing Post-Normal Technologies for Sustainability. *Ecological Economics* 65 (2): 225-41.

Fuller, R. B. 1963. *Ideas and Integrities: A Spontaneous Autobiographical Disclosure.* Englewood Cliffs, NJ: Prentice-Hall.

Funtowicz, S. O., and Ravetz, J. R. 1991: A new Scientific methodology for Global Environmental Issues, in Costanza, R.: Ecological Economics. The Science and Management of Sustainability. New York, Oxford: Columbia Press, pp. 137-152.

Gibbons, M. 1999. Science's new social contract with society. *Nature, 402* (6761 Suppl). C81–84.

Hidalgo, C. A. 2011. "The Value in the Links: Networks and the Evolution of Organizations." In P. Allen, S. Maguire, and B. McKelvey, eds., *Sage Handbook on Management and Complexity,* ch. 32. Thousand Oaks, CA: Sage Publications.

Hidalgo, C. A., B. Klinger, A.-L. Barabasi, and R. Hausmann. 2007. "The Product Space Conditions the Development of Nations." *Science* 317: 482-87.

Jackson, S. J. "Rethinking Repair," in *Media Meets Technology*, eds. Pablo Boczkowski, Kirsten Foot, and Tarleton Gillespie (MIT Press: forthcoming, 2013).

Jiang, S., J. Ferreira, and M. C. González. 2012. "Clustering Daily Patterns of Human Activities in the City." *Data Mining and Knowledge Discovery* 25 (3): 478-510.

Kidane, Y. H., and P.A. Gloor. 2007. "Correlating Temporal Communication Patterns of the Eclipse Open-Source Community with Performance and Creativity." *Computational & Mathematical Organization Theory* 13, 17-27.

Lee, S., and W.-M. Roth 2001. How Ditch and Drain Become a Healthy Creek: Representations, Translations and Agency during the Re/Design of a Watershed. *Social Studies of Science* 31: 315-56.

Nowotny, H. 2003. Democratising expertise and socially robust knowledge. *Science and Public Policy*, *30*(3), 151–156.

Rosvall, M., & Bergstrom, C. T. 2007. Maps of random walks on complex networks reveal community structure. *arXiv:0707.0609*. doi:10.1073/pnas.0706851105

Shapin, S., & Schaffer, S. 1989. *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life.* Princeton, NJ: Princeton University Press.

Shove, E., Pantzar, M., & Watson, M. (2012). *The Dynamics of Social Practice: Everyday Life and how it Changes*. SAGE.

Star, S. L., & Griesemer, J. R. 1989. Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social studies of science*, *19*(3), 387–420.

Tardif, T. Z., and Sternberg, R. J. 1988. "What Do We Know about Creativity?" In R. J. Sternberg, ed., *The Nature of Creativity: Contemporary Psychological Perspectives,* 429-40. Cambridge: Cambridge University Press.

Toole, J. L., M. Cha, and M. C. González. 2012. "Modeling the Adoption of Innovations in the Presence of Geographic and Media Influences." *PLoS ONE* 7(1): e29528.

Turner, F. 2010. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago Press.

Venturini, T. 2009. Diving in magma: How to explore controversies with actor-network theory. *Public Understanding of Science.*

Venturini, T. 2012. Building on faults: How to represent controversies with digital methods. *Public Understanding of Science*, *21*(7), 796–812.

A SEAD NETWORK ANALYSIS OF WHITE PAPERS

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Introduction

Much as been said and written about the two-culture paradigm (Snow 1963) separating the world between artists (humanists) and scientists (Katzir-Katchalsky 1972, Meyer 1974, Root-Bernstein 1984, Alfert 1986, Siler 1996, Grillo 2009, Guillemin 2010). On one side of this debate are those who accept and celebrate this cultural art/science divide (e.g., Lévy-Leblond 2010). On the other side are those who reject it altogether to promote a better integration of artscience practices (e.g., Edwards 2008, Wilson 2010). The White Papers submitted to the SEAD network aim precisely at identifying the roadblocks preventing transdisciplinary (or transcultural) research. As such, they present an insider's view of the collaborative process involving artists, designers, scientists and engineers working alongside on common projects. More importantly, these papers offer a representative sample to test the two-culture model by examining in detail the opinions expressed therein. In this survey, I propose a network analysis of the 40 White Papers submitted to the SEAD Network. If it is true that artists and scientists think differently, the papers authored by artists and scientists should fall in different clusters in the network, with papers co-authored by both artists and scientists falling in between. More precisely, I will test the hypothesis that the papers submitted by artists and scientists are significantly disconnected in the corresponding graph, as predicted by the art/science separation. Rejecting this hypothesis will provide support for the alternative artscience integration.

This meta-analysis, performed by a scientist, is organized as a scientific paper with materials and methods, results, and a discussion. It proposes one of many different ways of comparing and analyzing the content of the White Papers. I have opted here for an "objective" statistical analysis of the data, not to be influenced by my own opinions presented in one of the contributions. In other words, I will let the data speak for themselves. The discussion section will then present an interpretation of the results, with personal comments.

Materials and Methods

This analysis was performed on the basis of the 40 White Papers submitted to the SEAD networks and available on the corresponding website (http://seadnetwork.wordpress.com/). The full list is also presented in the Appendix. For comparing the papers with one another, Word Counter 2.10.1 (http://www.supermagnus.com) was applied, and the list of words with at least

five occurrences in each text was recorded. To do so, all words were treated as case-insensitive, converted to their singular forms, and common words were ignored in the analysis. Following this first step, all similar words were then recoded to a single word stem; the corresponding occurrences were tabulated for each paper. The final dataset thus presents 664 words appearing at least five times in one of the 40 White Papers.

Pairwise intertextual (lexicometric) distances (sensu Labbé & Labbé 2001, Merriam 2002) were computed among all papers in R 2.13 (R Development Core Team 2011) based on presence/absence data (function dist). This index measures the distance as a proportion of words used in one text, but not in both. As such it ignores actual word frequencies to prevent shorter papers to be misrepresented in the analysis with respect to the longer papers (Brunet 2003). A null distance (0) between any two papers means that they share exactly the same words, whereas a maximal distance (1) implies that the two papers are characterized by entirely different sets of words.

The 40x40 distance matrix was then submitted to different types of analysis. For one, a hierarchical clustering algorithm was applied to identify relevant groups in the dataset using the R package cluster. Ward's criterion (function hclust) was selected to minimize within-cluster variance and maximize among-cluster variance (Ward 1963), and the resulting dendrogram was used as a template to identify significant clusters. Furthermore, a k-means partitioning algorithm (Hartigan & Wong 1979) was applied to define the optimal number of clusters in the data (function kmeans) and the corrected Rand index (Hubert & Arabie 1985) was used to compare this partition (function randIndex) with an a priori categorization of papers based on the "cultural status" of the author(s).

Three different categories were used to classify the 40 White Papers. Texts with a single author were coded as either "artist" or "scientist" depending of the self-proclaimed status of the author, or as "artscientist" for authors with a dual status (based on unpublished demographics data). Texts with multiple authors were coded as "artist" or "scientist" only when all co-authors were in the same category; they were coded as "artscientist" in every other instance. This classification was further refined by examining the frequencies of the words *art* and *science* in each paper to categorize hybrid contributions. Out of the 40 White Papers, 16 were coded as authored by artists, 7 by scientists, and 17 by artscientists (see Table 1).

A network was also built from the distance matrices converted into adjacency matrices with the R package igraph (function graph.adjacency) using different cutoff levels. That is, papers (nodes) with more words in common are connected by a link (edge), whereas more distant papers are

disconnected in the graph. In the final representation, a 10 percent resemblance threshold was selected as an interesting cutoff value for building the network. Lower values produced completely connected graphs and higher values produced disconnected graphs without any structure. The nodes were colored in the final graph with respect to the three different categories of papers.

A statistical evaluation of network indices associated with each category of papers was performed. Namely, the three groups were characterized with degree distribution, clustering coefficient, diameter, and density:

The degree of a node is the number of edges connected to that node. The mean degree for a given category thus quantifies the average number of papers connected with a paper from that category.

The clustering coefficient of a node z is defined as the probability that two nodes x and y which are connected to the node z are themselves connected (Milenković, Lai, and Pržulj 2008); the average over all nodes z of a given category is the clustering coefficient of that category.

The smallest number of edges that have to be traversed to get from a node x to a node y in a network is called the distance between nodes x and y, and a path through the network that achieves this distance is called the shortest path between nodes x and y. The average of shortest path lengths over all pairs of nodes in a network is called the average network diameter (Milenković, Lai, and Pržulj 2008). For a given category, the average diameter is computed by only counting the shortest paths among nodes of that category.

The density of a graph is simply the ratio of the actual number of edges over the maximum possible number of edges in a fully connected graph. For a given category, density is computed by only considering the subgraph with nodes of that category.

The significance of the corresponding statistics was assessed with pairwise Mann-Whitney tests among the various categories. Moreover, these values were also evaluated with respect to a random graph model (Erdős & Rényi 1959) in which all nodes have the same probability of being connected. To do so, 1000 networks with exactly the same number of nodes and edges as the original network were generated (function erdos.renyi.game) and the categories were also assigned at random by permuting the corresponding colors in the random graphs. For each replicate, the degree distribution, clustering coefficient, diameter and density of each category were computed for comparison with the original values. Under the art/science division

hypothesis, nodes associated with each colors should be significantly more clustered and more densely connected than the same colors would be in random graphs.

Results

The hierarchical classification of intertextual distances is presented alongside the network analysis of the 40 White Papers in Figure 1. That joint representation identifies four clusters in the dendrogram (with distinct colors) corresponding to partly overlapping subgraphs (communities) in the associated network. As such, this classification of papers according to a minimum variance criterion or a graph-theoretical approach reveals a congruent structure in the analysis of the dataset using different analytical methods.
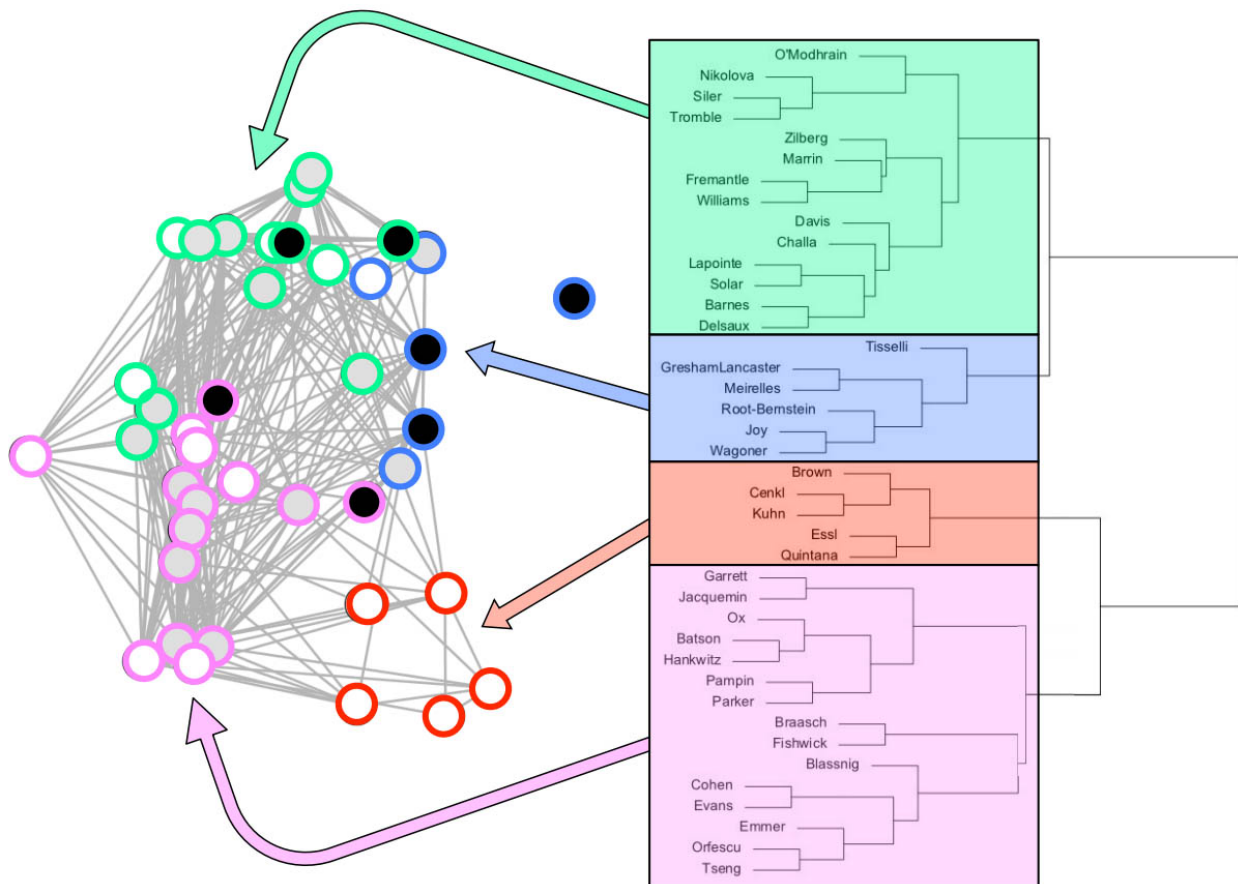

Figure 1. Joint representation of the clustering and network analysis of the 40 White Papers based on intertextual distances. The different colors associated with the four clusters defined on the dendrogram are used to identify the corresponding nodes in the network. The three categories

of papers are also identified on the graph by nodes labeled in white (artist), black (scientist) or grey (artscientist).

More interestingly for the purpose of this meta-analysis is the clustering of nodes representing the three different categories of papers in the network (here depicted in white, black and gray). Under the art/science separation hypothesis, nodes associated with "artists" (white) and "scientists" (black) should be more densely connected within each category than among categories. Moreover, the "artscientists" (gray) should be equally connected to nodes representing either one of the other two categories. This hypothesis was tested by assessing the statistical significance of various network indices for the three different categories.

Results of all pairwise Mann-Whitney tests were not significant, but examination of actual statistics indicates higher degree, clustering coefficient, and density values as well as a smaller diameter for papers assigned to the artscientist category with respect to the artist and scientist categories (Table 1). When these test statistics were compared to those obtained from 1000 random graphs, the artscientist was the only category with observed values more extreme than those expected by chance alone ($p < 0.001$, following Bonferroni correction for multiple tests). In other words, whereas all network indices could not discriminate among papers authored by artists or by scientists, the papers authored by artscientists were clearly more clustered and connected to each other, as well as to other categories.

Table 1. Summary of the network statistics computed from the graph depicted in Figure 1.

Paper Categories	No. Papers	Average degree	Clustering coefficient	Average diameter	Subgraph density
Artists	16	16.81	0.65	1.64	0.38
Scientists	7	14.15	0.51	2.36	0.29
Artscientists	17	**20.00**	**0.73**	**1.39**	**0.54**

The k-means partition algorithm identified three distinct clusters of papers. The corrected Rand index comparing this objective partition with that defined a priori based on cultural status was statistically significant ($D = 0.067$, $p = 0.048$) with respect to 1000 random assignment of the 40 papers in three groups containing the same number of elements as in the original classification.

Discussion

In this meta-analysis of the 40 White Papers submitted to the SEAD network, I relied on the "scientific method," employing a wide range of statistical and graph-theoretical approaches similar to those I use routinely for the analysis of gene similarity networks (Beauregard-Racine et al. 2011). I intended to look at the "two cultures" from an objective standpoint, testing the corresponding hypothesis that texts authored by artists/scientists would be separated in a network representation of intertextual distances. To my great surprise, this is not what the data said. As a matter of fact, all analyses and statistical evaluation of network indices associated with the different categories of papers revealed an integration of artists and scientists in overlapping groups/partitions. A single cluster in the dendrogram (in red) was formed only with artists. All other clusters included papers representing the three different categories. As such, these results seem to falsify the art/science divide altogether. In terms of word use at least, it is not possible to distinguish papers authored by scientist(s) from those authored by artist(s). Yet, the classification of papers using the k-means algorithm revealed a partition statistically congruent with the cultural status of the author(s) defined a priori. There may well be a (partial) division between artists, scientists and artscientists, but this could to be further evaluated with a fuzzy clustering method allowing for overlapping clusters (Nikhil, Bezdek, and Hathaway 1996).

From a different perspective, however, the network analysis tells an even more interesting story than the nonseparation of artists and scientists. The statistical analysis of graph-based indices exhibited the special status of artscientists, a category different from artists and scientists. That is that, papers authored by hybrid individuals (artscientists) as well as those submitted by co-authors with multiple status (artists + scientists) are significantly more clustered in the network representation that papers authored by artists and/or scientists alone. These contributions to the SEAD Network are characterized by larger clustering coefficients and higher density, among others. This implies that artscientists are probably better at collaborating with each other, but more importantly, that they could also collaborate with artists and scientists.

This paper revealed the power of network analysis for the study of intertextual comparisons. Using presence/absence information, I was able to detect significant patterns in lexicometric data. Yet, this simple analysis is far from being complete. The literature abounds with other types of similarity/distance measures among texts. I opted here for a binary measure, while others have relied on distances that account for word frequencies (Merriam 2002, 2003). Just as for the analysis of ecological data, taking species abundance as opposed to presence/absence might reveal different patterns in the community structure (Hubalek 1982). Likewise, various metrics

may provide different results, particularly when very long texts are compared with shorter ones. In such situations, the longer texts usually end up being clustered together, just because they are more likely to share words. A wide range of corrected indices is available to circumvent this problem (Brunet 2003), but it was not the scope of the present paper to assess the relative performance of different intertextual distances. Alternatively, I could have use a measure of semantic relatedness to compare the papers based on their meanings, not just word contents. A plethora of algorithms are currently being published for doing so in different fields (Pevzner 1992, Budanitsky & Hirst 2006, Ferreira & Couto 2010). In the present case, I am willing to admit that comparing papers using a semantic metric would produce a more precise characterization of intertextual distances, and possibly different outcomes.

Concluding Remarks

As a final note, a caveat is mandatory. The results and conclusion of this meta-analysis are based entirely upon the classification of papers into one of three possible categories – that of the "cultural status" of the author(s): artist, scientist, and artscientist. I suspect that if one were to survey the authors of the White Papers to build such a classification, most of them would probably check "all of the above" if asked about their status. For that matter, I decided for the present analysis to categorize the papers not only based on their author's status, but also their contents. I fully understand and accept that this categorization is somewhat inaccurate and can be improved. Namely, I have voluntarily ignored other categories such as engineer, designer, or humanities, for the sake of simplicity. It is particularly telling to have obtained significant results based on such a crude classification. The White Papers have spoken: artists and scientists are not distinguishable, but artscientists are a different breed – individuals who thrive in transdisciplinary (and paradisciplinary) contexts. This is, of course, what the SEAD network is all about; this meta-analysis provides statistical support for promoting such collaborative endeavors.

Acknowledgments

APPENDIX

List of 40 White Papers with corresponding categories assigned for the network analysis

Artscientists	Artscientist
Barnes, Steven J., and Carlos Castellanos. 2012. "(Re)Structuring Innovation: Community-Based Wet Labs for Art-Science Collaborations." Evans, Kathryn, and Roger Malina. 2012. "Bridging the Silos: Curriculum Development in the Arts, Sciences and Humanities" Jacquemin, Christian. 2012. "Emergence of New Institutions for Art-Science Collaboration in France and Comparison of Their Features with Those of a Longer Established One." Marrin, D.L. 2012. "Interactions among Scientists/Engineers and Artists/Designers in Developing a Common Language and Unique Perspectives on Today's Challenges." Meirelles, Isabel. 2012. "The Cross-Disciplinary Challenges of Visualizing Data." Nikolov(a), Jennifer. 2012. "Towards a Taxonomy of the Challenges Within Typologies of Collaborations Between Art – Design – Engineering – Science – Humanities – A Practical Guide." Ox, Jack, and Richard Lowenberg. 2012. "SARC (Scientists/Artists Research Collaborations)." Parker, Jennifer. 2012. "The Openlab Network Facilitates Innovative, Creative and Collaborative Research with Art, Community, Design, Technology, and Science at the University of California, Santa Cruz." Root-Bernstein, Robert, and Michele Root-Bernstein. 2012. "The Importance of Early and Persistent Arts and Crafts Education for Future Scientists and Engineers." Zilberg, Jonathan, Barry Kitto, Helen-Nicole Kostis, Linda Long, and Kathryn Trenshaw. 2012. "Can Art Advance Science? A Hypothetical SEAD Experiment."	Batson, Glenna. 2012. "Ex-Scribing the Choreographic Mind—Dance & Neuroscience in Collaboration." Challa, Krishna Kumari. 2012. "Science-Art Interactions in Asia With Particular Reference to India." Emmer, Michele. 2012. "Interdisciplinary Courses, Positions, PhD, in Italy." Hankwitz, Molly. 2012. "Environmental Equity: Enabling Excellence in Media Art and Science in Under-Served Communities." Lapointe, François-Joseph. 2012. "How I Became an Art[Scient]ist: A Tale of Paradisciplinarity." O'Modhrain, Sile. 2012. "Building an Interdisciplinary Research Team." Solar, Myriam. 2012. "Complexity Art: A Pattern of Transdisciplinary Emergent Properties."

Artists	Artist
Braasch, Jonas. 2012. "Creative Artificially-Intelligent Agents for the Arts: An Interdisciplinary Science-and-Arts Approach."	Brown, Ron. 2012. "Using 'Processing' as a Stimulus for Producing STEAM."
Orfescu, Cris. 2012. "The Nanoart 21 Project."	Cenkl, Pavel. 2012. "A New Ecology of Learning: Ecological Systems as Pedagogical Models."
Pampin, Juan, and James Coupe. 2012. "The Coming of Age of a PhD Program in Digital and Experimental Arts Practice: Lessons Learned and Challenges for the Future."	Cohen, Nathan. 2012. "Bridging the Divide: Collaboration, Communication and Education in art And Science."
Quintana, Joan, and Jose Quintana. 2012. "How SEAD Network Can Advance Experimental Economics: A Case Study of Innovation and Entrepreneurship in Support of Rural Community and Economic Development."	Davis, Josie E. 2012. "A Case Study in IP Arising in Art/Science Performance Research and Transdisciplinary Collaboration."
Tseng, Yu-Chuan, and Antoanetta Ivanova. 2012. "Chaos, Computers, and Cyborgs. Developing the Art and Technology Practices in Taiwan."	Delsaux, Jean. 2012. "From Workshop to Academic Laboratory, an Artistic Experience of Transdisciplinarity."
Williams, Roy, Jenny Mackness, and Simone Gumtau. 2012. "Learning Across Cultures."	Essl, Georg. 2012. "Between Barriers and Prospects: Merging Art Performance and Engineering in Mobile Music Education and Research."
	Fremantle, Chris, John Mullins, and Donald Urquhart. 2012. "CoRE Challenges: the Artist in Residence Programme at the British Heart Foundation Centre for Research Excellence, Queens Medical Research Institute, University of Edinburgh."
	Garrett, Marc. 2012. "DIWO (Do-It-With-Others): Artistic Co-Creation as a Decentralized Method of Peer Empowerment in Today's Multitude."
	Gresham-Lancaster, Scot. 2012. "Data Sonification; An Emerging Opportunity for Graduate Music/Sound Design Departments to Expand Research in an Art and Science Collaboration."
	Kuhn, Sarah. 2012. "Thinking with Things: Feeling Your Way into STEM."

Scientists	Scientist
Blassnigg, Martha, and Michael Punt. 2012. "Transdisciplinarity: Challenges, Approaches and Opportunities at the Cusp of History." Siler, Todd, and Geoffrey Ozin. 2012. "Cultivating Artscience Collaborations that Generate Innovations for Improving the State of the World." Wagoner, Cynthia L., and Robin Wilkins. 2012. "Process Driven Potentials for Interdisciplinary Learning: Ubeats, a Model for Science and Music Learning."	Fishwick, Paul. 2012. "Learning Computing through Game Experiences." Joy, Anu. 2012. "Mapping Space: Introducing Geographical Information Systems in Indian School Classrooms." Tisselli, Eugenio, Juanita Schlaepfer-Miller, and Angelika Hilbeck. 2012. "Sauti Ya Wakulima: Using Mobile Phones to Make the Voices of Rural Farmers in Tanzania Heard." Tromble, Meredith. 2012. " Vitamin A: A Modest Proposal to Introduce Trace Amounts of Contemporary Art into Research by Preparing Students in Art, Design, Engineering, and Science for Collaborative Creative Work, With the Intention of Saving Earth."

References

Alfert, M. 1986. "Creativity and merit in art and science." *Leonardo* 19: 323-28.

Beauregard-Racine, J., C. Bicep, K. Schliep, P. Lopez, F.-J. Lapointe, and E. Bapteste. 2011. "Of Woods and Webs: Possible Alternatives to the Tree of Life for Studying Genomic Fluidity in E. Coli." B*iology Direct* 6: 39.

Brunet, E. 2003. "Peut-on mesurer la distance entre deux textes?" *Corpus* 2. http://corpus.revues.org/30

Budanitsky, A., & Hirst, G. (2006). "Evaluating WordNet-based Measures of Semantic Distance."
Computational Linguistics, 32:13-47.

Edwards, D. 2008. *Artscience: Creativity in the Post-Google Generation*. Cambridge, MA: Harvard University Press.

Erdős, P., & Rényi, A. 1959. "On random graphs." *Publicationes Mathematicae* 6: 290-97.

Ferreira, J., & Couto, F. 2010. "Semantic Similarity for Automatic Classification of Chemical Compounds." *PLoS Computational Biology 6*: e1000937.

Grillo, Y. A. 2009. "When Does Art Become Science and Science Art?" *Leonardo* 42: 103-4.

Guillemin, R. 2010. "Similarities and Contrasts in the Creative Processes of the Sciences and the Arts." *Leonardo* 43: 59-62.

Hartigan, J. A., & Wong, M. A. 1979. "A K-means Clustering Algorithm." *Applied Statistics* 28: 100-8.

Hubalek, Z. 1982. "Coefficients of Association and Similarity, Based on Binary (Presence Absence) Data: An Evaluation." *Biological Reviews* 57: 669-89.

Hubert, L., and Arabie, P. 1985. "Comparing Partitions." *Journal of Classification* 2: 193-218.

Katzir-Katchalsky, A. 1972. "Reflections on Art and Science." *Leonardo* 5: 249-53.

Labbé, C., and D. Labbé. 2001. "Inter-textual Distance and Authorship Attribution: Corneille and Molière." *Journal of Quantitative Linguistics* 8: 213-31.

Lévy-Leblond, J.-M. 2010. *La science (n')e(s)t (pas) l'art: Brèves rencontres.* Hermann, Paris.

Merriam, T. 2002. "Intertextual Distances between Shakespeare plays, with Special Reference to Henry V (Verse)." *Journal of Quantitative Linguistics* 9: 261-73.

———. 2003. "Intertextual Distances, Three Authors." *Literary and Linguistic Computing* 18: 379-88.

Meyer, L. B. 1974. "Concerning the Sciences, the Arts—and the Humanities." *Critical Inquiry* 1:163-217.

Milenković, T., J. Lai, and N. Pržulj. 2008. "GraphCrunch: A Tool for Large Network Analyses." *BMC Bioinformatics* 9: 70.

Nikhil, R. P., J. C. Bezdek, and R. J. Hathaway. 1996. "Sequential Competitive Learning and the Fuzzy c-Means Clustering Algorithms." *Neural Networks* 9: 787-96.

Pevzner, P. A. 1992. "Statistical Distance between Texts and Filtration Methods in Sequence Comparison." *Computer Applications in Bioscience* 8:121-27.

R Development Core Team. 2011. "R: A Language and Environment for Statistical Computing." Vienna, Austria: R Foundation for Statistical Computing. http://www.R=project.org/

Root-Bernstein, R. S. 1984. "Creative Process as a Unifying Theme of Human Cultures." *Daedalus* 113: 197-219.

Siler, T. 1996. "Creating Artscience." *Art Journal* 55: 42.

Snow, C. P. 1963. *The Two Cultures: And a Second Look.* Cambridge: Cambridge University Press.

Ward, J. H., Jr. 1963. "Hierarchical Grouping to Optimize an Objective Function." *Journal of the American Statistical Association* 58: 236-44.

Wilson, S. J. 2010. A*rt + Science Now: How Scientific Research and Technological Innovation Are Becoming Key to 21st-Century Aesthetics.* London: Thames and Hudson.

A META-ANALYSIS OF SEAD WHITE PAPERS, WITH A FOCUS ON RESEARCH AND CREATION

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I. Introduction

This meta-analysis will be developed according to the methodology proposed in the SEAD White Paper, "Exploring a Model of Transdisciplinary Research Collaboration based on Collective Action Theories," (Miranda de Almeida and Tejerina) from the perspective of Theory of Action.

This methodology offers a tridimensional matrix to deal with six different kinds of action, four kinds of stakeholders and four spheres of integration/collaboration. The matrix opens the possibility of classifying transdisciplinary action in a grid of 96 possible situations that can be useful for analyzing how transdisciplinary action is being achieved and to plan the future action that needs to be developed by each stakeholder within the scope of their aims, possibilities and responsibilities to produce a qualitative change in transdisciplinary practices.

The meta-analysis will be done for ten White Papers that have been selected to be presented at the XVIII ISA World Congress of Sociology, Yokohama, Japan, 13-19 July 2014, in the session "Facing Inequality: A Proposal for Sociological Debate." This falls under the Session Proposal for Research Committee RC23: Sociology of Science and Technology. All the papers address research and creative practice and transdisciplinarity.

The group of authors and White Papers that are taken into consideration are:

1. Martha Blassnigg and Michael Punt, UK. "Transdisciplinarity: Challenges, Approaches and Opportunities at the Cusp of History"
2. Josie E. Davis, USA. "A Case Study in IP Arising in Art/Science Performance Research and Transdisciplinary Collaboration"
3. Kathryn Evans, USA. "Briding the Silos: Curriculum Development in the Arts, Sciences and Humanities"

4. François-Joseph Lapointe, Canada. "How I Became an Art[Scient]ist: A Tale of Paradisciplinarity"
5. D. L. Marrin, Mexico. "Interactions among Scientists/Engineers and Artists/Designers in Developing a Common Language and Unique Perspectives on Today's Challenges"
6. Cristina Miranda de Almeida and Benjamin Tejerina, Spain. "Exploring a Model of Transdisciplinary Research Collaboration Based on Collective Action Theories"
7. Jack Ox and Richard Lowenberg, USA. "SARC (Scientists/Artists Research Collaborations)"
8. Myriam Solar, Spain. "Complexity Art: A Pattern of Transdisciplinary Emergent Properties"
9. Deborah Tatar, USA. "Gender and STEM: No Shift Required"
10. Bronac Ferran, UK. "SEAD: From Success to Succession"

II. Structure of the Meta-Analysis

In this meta-analysis, six kinds of transdisciplinary actions (increase of resources, support networking, education of researchers, support research, diffusion, sensitization, and creation of interaction structures) are situated according to four stakeholders' scales (individuals, communities, public, and private institutions) articulated around four scales of interaction regarding opportunities and obstacles: (1) face-to-face interactions (FFI), such as linguistic opportunities and problems, cross-communications misunderstandings, emotions and insights, etc.; (2) transdisciplinary power synergies, struggles, and competitions such as those that belong to authority and power elites inside each discipline that form interest groups (IG); (3) institutional educational and research structures (ERS) that are discipline-based and can be seen as structures for new opportunities or threats to any kind of transdisciplinary action; (4) social paradigms that are common in public political-administrative systems (PPAS) of funding at different levels, whether national, regional, European, or international, that are not adapted to transdisciplinary action.

Opportunities and obstacles for action will be identified according to the following kinds of action, stakeholders, and spheres of integration.

2.1. Six kinds of actions

a. Increasing of resources;
b. Developing and supporting networking (engagement, participation, and networking actions);
c. Educating researchers to manage transdisciplinary collaboration;

d. Supporting research;

e. Creating diffusion, dissemination, and sensibility;

f. Creating an interaction structure.
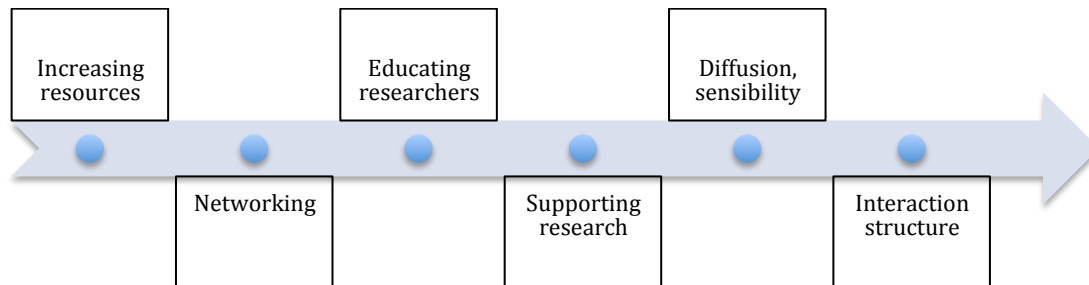
a. Actions for increasing of resources (AR), including advocacy

These actions aim at getting more access to funding, human and technological resources to research and collaboration across disciplinary borders.

b. Actions to support networking (NA)

The aim of these kinds of actions is to foster engagement, participation, formal and informal actions for exchanging knowledge and networking actions. These are resilience and solidarity actions for supporting networked projects (NSEAD can be a kind of big umbrella for different projects and institutions towards the aim of fostering networked achievements).

c. Education actions (EA) to prepare researchers to manage transdisciplinary collaboration

Education actions are aimed at preparing researchers to manage collaboration across disciplines, develop a common language and deal with differences. In particular it is necessary to solve questions around methodological and theoretical dominance of one discipline on others and questions around theoretical and methodological integration and developing adequacy (Repko 2008). As Repko said, in multi-disciplinary approaches the 'home' discipline usually imposes the preferred method and theory, transdisciplinary approaches do not privilege any disciplinary method or theory and trans-disciplinary approaches integrate all knowledge, disciplinary methods and stakeholder views on the basis of some overcharging theory.

d. Action to support research (ARS) for researchers

Listening and follow up, to maintain a system of tracking opinion from researchers in the network. To update the cartography of researchers on the network and their results of their collaborations, creating feedback between peers.

e. Diffusion, dissemination and sensitization actions (DA) to create visibility toward society and sensitize different social groups

Sensitization actions aim at increasing awareness about transdisciplinary collaboration. They can be carried out in the form of dissemination actions (actions for increasing sensitivity of different spheres regarding transdisciplinary collaboration).

f. Action to create an Interaction Structure (AIS)

The interaction structure for transdisciplinary collaboration can be better realized within an institutional space from which all kinds of actions can be coordinated. This space can take form as an Observatory for Networked Science, Engineering, Art and Design. The goal is to enable agents that support transdisciplinary approaches to be in positions of power in decision-making processes. This can be achieved by complementing the SEAD network with an International Observatory for NSEAD Knowledge, to fully protect transdisciplinary collaboration.

A SEAD Observatory for Networked Science, Engineering, Art and Design should be able to plan, coordinate, implement, and manage all aspects of transdisciplinary collaborations. The Observatory would be supported by social network and social media platforms (transmedia approach), and coordinate the implementation of all kinds of actions (AR, NA, EA, ARS, DA).

The objectives of the SEAD Network Observatory could be:

To situate NSEAD transdisciplinary collaboration in the main political objectives and institutional guideless of research at any level to accelerate the development of sustainable, innovative and inclusive transdisciplinary Knowledge in society;

To foster, implement and look for funding to network knowledge and collaboration in the NSEAD transdisciplinary field. The NSEAD Observatory can be supported in a network of observatories such as European NSEAD Observatory, National NSEAD Observatories. These observatories can be created also at lower levels;

To overcome hurdles in the development of an transdisciplinary knowledge society;

To foster interoperability of solutions across countries; to treat transdisciplinary knowledge in the global and local scales;

To generate awareness in different stakeholders in the research and knowledge sector to mobilise the needed financial and human resources to carry out actions;

Stimulation actions for transdisciplinary research: Promote annual research grants for researcher groups with the requirement that at least two fields participate in the collaboration.

2.2. Four kinds of stakeholders

a. Individuals (I)
b. Communities (C)
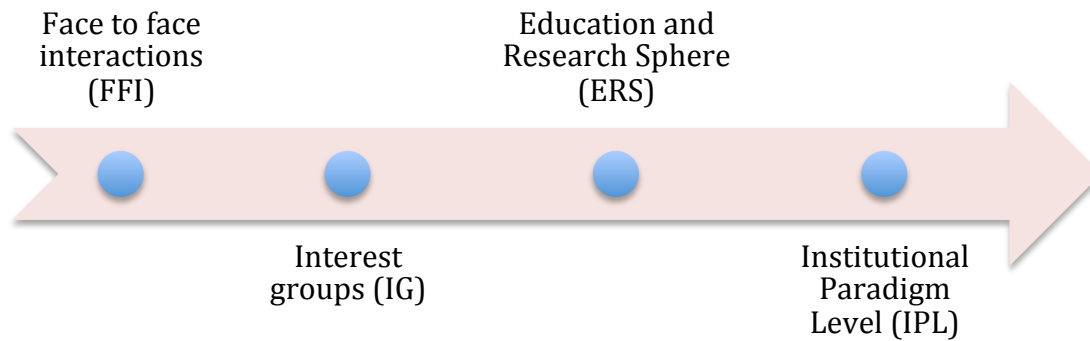c. Public Institutions (PubI)
d. Private Institutions (PrI)

Actions analysis should take into consideration basically two kinds of agents: sympathy and resistance agents. Sympathy agents are individuals, collectives and organized groups that work to facilitate transdisciplinary dialogue and collaboration around similar or equal objectives. Resistance agents are other social and political actors with which they come into competence or conflict.

a. Individuals
(I)

c. Public
Institutions
(PubI)

b.
Communities
(C)

d. Private
Institutions
(PrI)
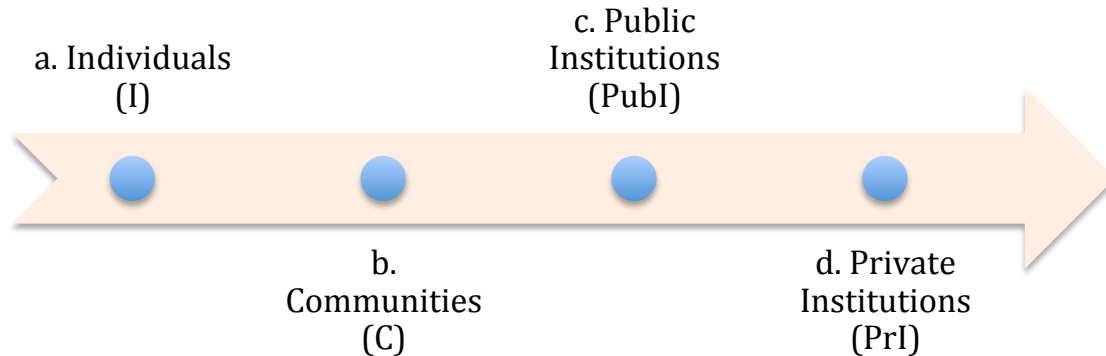
The analysis takes into consideration four types of stakeholders such as individual, communities (structured and formally organized, such as professional associations, and ad hoc interest alliances, linked to disciplinary fields), and public and private institutions (not linked to disciplines like banks for example), acting at four scales (local L, regional R, national N and international I scales) apart from six kinds of actions.

2.3. Four spheres of interaction
Opportunities and obstacles are identified according to four different spheres o interaction.

Face to face
interactions
(FFI)

Education and
Research Sphere
(ERS)

Interest
groups (IG)

Institutional
Paradigm
Level (IPL)

a) Face-to-face interactions (FFI). In the scale of face-to-face interactions FF (such as linguistic opportunities and problems, cross-fertilized support, misunderstandings and insights, etc.);

b) Interest groups (IG). In the scale of interdisciplinary power synergies, struggles and competitions such as those that belong to authority and power elites (interest groups) inside each discipline;

c) Education and research sphere (ERS). In the scale of institutional educational and research structures that are discipline-based and can be seen as structures for new opportunities or threatens to any kind of interdisciplinary action;

d) Institutional paradigm level (IPL). In the scale of the institutional paradigm that is common in public political-administrative systems of funding at different levels, such as national (Na), regional (R), European (EU) or international (IN), which are not adapted to interdisciplinary action. For example, it is considered appropriate that a scholar follow a unique linear disciplinary path during her or his academic trajectory; any break in this linear path needs to be justified so that the carrier is considered worthy of the academy; this reflects a Cartesian mode of thinking about academia and constitutes an obstacle for interdisciplinary fluidity.

Papers will be analyzed and information will be organized according to the aspects mentioned in association with each action.

III. Actions meta-analysis

Actions type a: Increasing of resources

1. Acknowledging and integrating new forms of bottom up knowledge; construction, production, dissemination and storage that are current in digital culture (I, C, PubI, PrI) (FF, IG, ERS);
2. Opening disciplinary institutional borders: accepting scientist and artists as both teachers and researchers in institutions traditionally reserved to each one of the disciplines (PubI, PrI) (IG, ERS, IP);
3. Accepting scientific projects in art venues and art projects in scientific venues (C, PubI, PrI) (IG,ERS, IP);
4. Accepting art publications (with scientific method) in science journals and scientific publications in art journals (C) (IG, IP);
5. Breaking new ground with unusual funding categories, such as sewable computing (PubI, PrI) (IG, IP);
6. Re-evaluating potential partnerships between art and science (C, PubI, PrI) (IP);
7. Positive discrimination mechanisms to support transdisciplinary curriculums (PubI, PrI) (IG, ERS, IP);
8. Creating a common language (C) (FF, IG, ERS, IP);

Actions type b: Supporting networking

1. Preparing, developing, and implementing physical and online spaces for sharing that foster enduring communities (I, C, PubI, PrI) (FF, IG, ERS, IP);
   (a) Developing a website (C, PubI, PrI) (FF, IG, ERS, IP);
   (b) Creating and housing of a database (C, PubI, PrI) (FF, IG, ERS, IP);
   (c) Implementing physical residences and environments for artists and scientist to share on a face-to-face basis (C, PubI, PrI) (FF, IG, ERS, IP);
   (d) Promoting physical opportunities for meeting around complex educative problems, such as environmental clean-ups, or engaging with the DIY movement to integrate minorities—such as women, elders, children, or immigrant communities—in art-science-tech workshops (I, C, PubI, PrI) (FF, IG, ERS, IP);
   (e) Creating specialized journals of all kinds (scientific and general-audience) for publication of experiences, processes, projects (for example, *Lego* magazine, or the journal *Leonardo*) (C, PubI, PrI) (FF, IG, ERS, IP);

2. Igniting connections between institutions that support and fund art-tech-science on a separate basis (cluster them) (for example, MIT's High-Low Tech Lab) (IG/ERS/IP);
3. Creating a cloud-based database for curriculums (I, C, PubI, PrI) (FF, IG, ERS, IP);
4. Creating a cloud-based database for syllabi, resources, and bibliographic resources (C, PubI, PrI) (FF, IG, ERS, IP).

Actions type c: Educating researchers to manage transdisciplinary collaboration

1. Clarifying concepts (trans/multi/inter/trans) that qualify collaboration across disciplines (I, C) (FF, IG, ERS);
2. Preparing experts on transdisciplinary dialogue and practices to support research (PubI, PrI) (ERS);
3. Supporting risk taking, innovative ground-breaking visions and long-term results (complementary to short-term results) (PubI, PrI) (IG, IP);
4. Educating regarding intellectual property (IP) issues that emerge in transdisciplinary SEAD-based environments and projects (PubI, PrI) (ERS, IP);
5. Developing transdisciplinary literacy tools to bridge the gap in transdisciplinary illiteracy regarding SEAD-based approaches; literacy about IP rights; illiteracy about how to share in heterogeneous environments in which no common language exists (PubI, PrI) (FF, IG, ERS, IP);
6. Inscribing SEAD in academic curriculums at undergraduate, graduate, and post- graduate levels (PubI) ERS, IP);
7. Educating artists and scientists on how to create a dialogue for collaboration (PubI, PrI) (ERS).
8. Teaching methods to facilitate collaboration in complex environments (PubI, PrI) (ERS);
9. Reformulating art curriculums according to a different framework based on complexity (art and aesthetic complexity); developing principles, methodology, and curriculums; introducing history of science, philosophy of science, scientific method, and science of complexity in the curriculums of art and vice versa (PubI, PrI) (ERS, IP);
10. Bridging the literacy gap regarding women and children in relation to technology and science (developing bottom-up workshops) (PubI) (ERS);
11. Fostering lifelong learning (PubI, PrI) (ERS, IP);
12. Turning universities and colleges into places to think on advanced methodologies to facilitate collaboration and networking instead of reinforcing disciplinary borders (PubI, PrI) (ERS, IP);
13. Developing didactic aspects from art and science to support teaching in both spheres

(art as a medium to teach science, and science as a medium to teach art)
(PubI, PrI) ((ERS).

Actions type d: Supporting research

1. Promoting speculative ground-breaking research (PubI, PrI) (ERS, IP);
2. Developing trend lines (or research lines) of transdisciplinarity (Klein, 2010);
3. Fostering meta-approaches in research (PubI, PrI) (ERS, IP);
4. Developing tools to help researchers (for example, templates for contracts or IP legal issues; orientation guidelines regarding roles, possible problems to different stakeholders, or administrative roles) (PubI, PrI) (IG, IP);
5. Developing a set of transdisciplinary criteria (maybe a manifesto?) (C) (IG);
6. Mapping efforts and making them visible (I, C, PubI, PrI) (IG);
7. Fostering paradisciplinarity (paradisciplinarity happens when the same individual masters the technical tools and epistemological discourses of the two fields and also contributes to both art and science) (PubI, PrI) (ERS);
8. Developing new quantitative and qualitative metrics and criteria to evaluate transdisciplinary contributions (PubI) (IP);
9. Making research protocols more flexible to accommodate nontraditional practices and technologies (benefiting from epistemological differences) (PubI, PrI) (IG, IP);
10. Creating pilot projects to test possibilities for transdisciplinary collaboration (PubI, PrI) (ERS);
11. Organizing conferences to concrete subjects to support the practice transdisciplinary research (for example, conferences on IP issues) (C, PubI, PrI) (IG, ERS);
12. Creating a research database with calls for contributions, available funding, and researchers (C, PubI, PrI) (FF, IG, ERS, IP);
13. Develop a comparative map of methodologies from different fields (PubI) (ERS).

Actions type e: Creating diffusion, dissemination and raising social sensibility

1. Organizing conferences on specific subjects to disseminate and make visible the results of transdisciplinary research (C, PubI, PrI) (FF, IG, ERS, IP);
2. Creating a research database for dialogue and diffusion to other fields (C, PubI, PrI) (FF, IG, ERS, IP);
3. Creating opportunities to engaging social groups to bridge the technological and scientific gap (attracting children and women into technological and scientific careers with a STEAM approach) (C, PubI, PrI) (FF, IG, ERS, IP).

Actions type f: Creating an interaction structure

1. Developing transdisciplinary online and offline environments
   (C, PubI, PrI) (FF, IG, ERS, IP);
2. Designing protocols for conflict resolution in transdisciplinary research (for example, regarding IP, trademark violations, and rights) (C, PubI, PrI) (FF, IG, ERS, IP);
3. Building a common language (C, PubI, PrI) (FF, IG, ERS, IP);
4. Building trust between SEAD partners (I, C, PubI, PrI) (FF, IG, ERS, IP);
5. Supporting complex teams with tools for collaboration, strategies to deal with different expectancies about results, and integrating aims (C, PubI, PrI) (FF, IG, ERS, IP);
6. Form technical experts to support mediation, organization, and dialogue in complex transdisciplinary groups (I, C, PubI, PrI) (FF, IG, ERS, IP);
7. Changing the paradigm: understanding integration as a dynamic process and art as the expression of complexity (C, PubI, PrI) (FF, IG, ERS, IP).

IV. Conclusions

It is important to observe that some actions have more impact regarding the number of stakeholders involved in their implementation and the number of spheres of integration touched. This means that these actions are more complex to achieve (as they require dialogue with multiple agents) but, at the same time, their impact is felt in a broader sphere of integration, and their resonance is greater.

The development of a scale of integration in which all these actions, stakeholders and spheres of integration are measured in relation to each other could be a next step in this meta-analysis.

Bibliography

Foster, C. 2011. "Three Colors: Coomassie Brilliant Blue, Sudan I and Somalia Yellow."
    Leonardo 44: 1.
Fremantle, C. 2012. "Reflections on Collaboration" Signpost,
    http://www.a-n.co.uk/publications/topic/2228109 Accessed Nov. 20, 2012

Diani, M., and R. Eyerman, eds. 1992. *Studying Collective Action.* Oxford: Oxford University Press.

Jenkins, J. 1983. "Resource Mobilization, Theory and the Study of Social Movements." *Annual Review of Sociology* 9: 527-53.

Kester, G. 2011. *The One and the Many: Contemporary Collaborative Art in a Global Context.* Durham, NC: Duke University Press.

Klandermans, B. 1997. *The Social Psychology of Protest.* Oxford: Blackwell.

Kriesi, H. 1995. "The Political Opportunity Structure of New Social Movements: Its Impact on Their Mobilization." In J. C. Jenkins and B. Klandermans, eds., *The Political of Social Protest: Comparative Perspective on States and Social Movements.* London: UCL Press.

Kluszczyński, R. W., ed. 2012. *Towards the Third Culture. The Co-existence of Art, Science and Technology.* Laznia, Poland: Laznia Center for Contemporary Art.

McAdam, D. 1982. *Political Process and the Development of Black Insurgency, 1930-1970.* Chicago: University of Chicago Press.

McAdam, D., S. Tarrow, and Charles Tilly. 2001. *Dynamics of Contention.* Cambridge: Cambridge University Press.

McCarthy I. D., and M. N. Zald. 1977. "Resource Mobilization and Social Movements: A Partial Theory." *American Journal of Sociology* 82: 1212-41.

Melucci, A. 1995. "The Process of Collective Identity." In H. Johnston and B. Klandermans, eds., *Social Movements and Culture,* 41-63. London: UCL Press.

Nowotny, H. 2009. "Frontier Research in the Social Sciences and Humanities: What Does It Mean, What Can It Mean?" Paper presented at the ISSC-ICPHS workshop, Humanities and Social Sciences: Intersections and Joined Paradigms, Bergen, Norway. Accessed 20 Nov. 2012. http://helga-nowotny.eu/

———. 2006. The potential of transdisciplinarity. Accessed 20 Nov. 2012. http://helga-nowotny.eu/texts.php

Ostrom, E. 2011. "Guest Introduction: Grassroots Economic Organizing." *GEO Newsletter* 2 (9). Accessed 1 Feb. 2013. http://geo.coop/node/647

Repko, A. 2008. Transdisciplinary Research: Process and Theory. Thousand Oaks, CA: SAGE Publications.

Smelser, N. J. 1963. *The Theory of Collective Behavior.* New York: Free Press.

Tarrow, S. 1989. *Democracy and Disorder: Protest and Politics in Italy 1965-1975.* Oxford: Clarendon Press.

———. 1994. *Power in Movement: Social Movements, Collective Action and Politics.* Cambridge: Cambridge University Press.

Tejerina, B. 2010. *La sociedad imaginada. Movimientos sociales y cambio cultural en España.* Madrid: Trotta.

Tilly, C. 1978. *From Mobilization to Revolution.* Reading, MA: Addison Wesley.

Turner, R. H. and L. M. Killian. 1957. *Collective Behavior.* Englewood Cliffs, NJ: Prentice-Hall.

Zald, M. N., and J. M. McCarthy. 1987. *Social Movements in an Organizational Society: Collected Essays. New* Brunswick, NJ: Transaction Books

A SEAD WHITE PAPERS WORKING GROUP META-ANALYSIS

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Abstract

This SEAD White Papers Working Group meta-analysis comments on a subset of the papers presented that relate to sound/music, dance, pedagogy, thinking with things, sci-art projects and common language. It focuses on emphasizing strengths for meta-discussion and advancing the SEAD agenda in a broader context in order to return us to the same debate as it was addressed in the 1950s and 1960s at the National Science Foundation (NSF). It critique the papers in terms of the way in which they respond to and rely on the underlying dominance of C. P. Snow's popular notion of two cultures (Snow 1963) considering that this unexamined thesis is taken as an article of faith dividing the worlds of art and science. Nowhere in any of these papers is the thesis and the history of the concept, or Snow's simplistic notion of culture, adequately or even rudimentarily addressed. In that regard it might come as a matter of surprise to the SEAD community that Snow's thesis was soundly rejected on empirical grounds at the start of this debate. Nevertheless it retains its popularity precisely for its unexamined simplistic stereotyping.

This meta-analysis highlights papers that transcend the distinction in practical ways in their substance and in their Suggested Actions. It emphasizes the Root-Bernstein paper as paradigmatic of how far cross-disciplinary research has come in theoretical and practical terms over the intervening decades. It then emphasizes two points: 1.This very same debate over the necessity of bridging work in science and culture (read as the arts, humanities and social sciences) was a subject of fundamental importance to scientists, anthropologists, and art historians participating in the NSF analysis of the problem as it was 60 years ago. 2. Revisiting the Leavis and Yudkin (1962) critique of Snow and that NSF history, it proposes that White Papers projects should carefully consider the emerging critical evaluations of previous art-sci projects such as those at the Wellcome Institute in the United Kingdom and the Xerox PARC project in the United States. In doing so, they would avoid making the mistake of proposing the justification of funding on the basis that art can contribute to basic science without providing evidence. Instead, what all these papers do document is how SEAD can advance science

education, the public image of science, and the creative impulse and rigor across the disciplines that bind them.

Introduction

The first part of this meta-analysis introduces some guiding questions in terms of qualifications and cautions that I have taken into consideration in commenting on some aspects of the papers that I, as a social scientist with a science background, have found especially compelling. The second part of the paper provides critical comments on select papers. The third and fourth parts present a historical perspective on the debate over the science/culture schism. Finally, the conclusion revisits the UK SciArt Project to provide a cautionary tale.

The essay discusses the problem of the instrumental hopes and logics for art-science collaboration and expands upon the common problems in many of these papers. These are as follows. First, the "two cultures" worldview constitutes the underlying ideology and epistemology of virtually all these White Papers. Second, this insufficiently considered paradigm significantly compromises the network's potential. Third, there is as a manifest rhetorical rather than evidence based claim over how the Suggested Actions can advance basic science. In short, I ask: Is there evidence here for the elemental principle of justification for funding SEAD, that the combination with non-science disciplines advances science? [1]

To begin with, a clarification of the SEAD network context and the various audiences addressed in the Suggested Actions is necessary. SEAD, NSEAD, XSEAD, the SEAD Network and the SEAD White Papers Working Group are different entities connected by a common history and concern. SEAD was created as a network to link and expand debate initiated by two separate initiatives, NSEAD and XSEAD, both of which were funded by NSF EAGER grants. [2] This clarity is necessary to avoid confusion, especially any notion that the Suggested Actions are calls for NSF funding. They are open-ended ideas about potential distributed funding initiatives for such cross-disciplinary projects in many different global contexts. Nevertheless, though they are specifically not to be read as funding proposals, there is a clear tendency for all participants to have used this as a context to put forth the Suggested Actions as calls for future funding.

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1 See Glinkowski and Bamford (2009) for evaluation of the UK sci-art projects

2 The project is an outcome of NSF Grant No. 1142510, IIS, Human Centered Computing Collaborative Research: EAGER: Network for S.E.A.D (NSEAD). I thank Carol Strohecker, Carol LaFayette, Roger Malina, Amy Ione and Robert Root-Bernstein for providing information and clarifying these and other important art-sci issues.

The SEAD White Paper project is then a forum for widely varying ideas about the arts and sciences. As regards the specific concerns of this meta-analysis, the project was not designed as an effort to claim that art can advance science or vice versa, though certain papers may advance one or either position (Carol Strohecker, pers. com). In the final analysis the White Papers initiative is an advocacy project. It seeks to socialize globally the value of research and work across the arts and sciences while creating a network. The SEAD objectives and the Suggested Actions in the papers are not necessarily the same. The White Papers project provides a means of measuring and recording the pulse and some of the diversity in the emerging global SEAD community (Carol La Fayette, pers. com.). Collectively however, the papers obviously have generative potentials for the purposes of grant preparation and curriculum innovation across the spectrum of potential funding agencies both governmental and non-governmental. In that context, this meta-analysis considers a few of the SEAD Suggested Actions in the White Papers relevant to the SEAD conversation as it might concern scientists and especially those making decisions at NSF about funding potential projects.

The Four Questions: Qualifications and Cautions

My guiding questions in this meta-analysis are these: 1. What do these White Papers potentially contribute to science? 2. How do they not do so? 3. What purpose do they serve if they will not advance science? And lastly: 4. If the papers do not provide evidence of how they will contribute to the advancement of science itself, but do advance science education and public relations, should we not be more careful about stating the reasons for seeking future funding from NSF for the movement from STEM to STEAM? These questions require attention because they are insufficiently substantiated as a primary logic in too many papers. Once again, though this SEAD White Papers project is explicitly not a fund-seeking mechanism, virtually all of the individual Suggested Actions are clearly composed with that intention in mind, they are in effect, calls for funding for each project's particular aims and agenda. As such they constitute public records of those visions of curriculum innovation and educational transformation.

I believe that it is important to inject greater rigor into the SEAD debate over evidence and what constitutes evidence for whether art can advance science. Specifically I argue that one should not make claims that art advances science as a justification for NSF funding initiatives if one cannot provide the evidence. One can use other compelling arguments as I expand upon throughout the essay. However, as this axiom is not a position unanimously held in this community, I emphasize that this contrary position is in no way intended to devalue Root-Bernstein's overview of the critical importance of the arts and crafts to science or any of the papers that do so. Indeed, as Root-Bernstein observes, "an increasing number of investigators are suggesting that for

exploring the human dimensions and implications of science and technology, artistic methods may even be superior to scientific ones" (2003, 272). There he quotes first Desmond Morris, "In reality, people today are not scientists or artists . . . they are explores or non-explorers," and then Sir Kenneth Clark, "Art and science . . . are not, as used to be supposed, two contrary activities, but in fact draw on many of the same capacities of the human mind" (2003, 276). [3]

One main goal of this meta-analysis is to explore the four questions I introduced above in the broader historical context out of which this contemporary debate has emerged. The idea of "two cultures" was created and popularized by C. P. Snow in 1959 and re-published in modified form in 1962 after much criticism inspiring a largely one-sided debate that continues (Snow 1959, 1962; Elkins 2008 contra Leavis and Yudkin 1962; Sielke 2010; Zilberg 2011). This idea of a fundamental schism in the modern world runs through virtually all of the papers as a dominant underlying theme. It is by and large taken uncritically as a self-evident truth which the authors universally seek to overcome. Indeed, the way in which Snow's axiom is taken as an article of faith without returning to the original texts and the criticisms of those texts across the decades is nothing short of remarkable. This issue is significant as we need conceptual clarity on basic principles in order to achieve any productive cross-disciplinary outcomes. To do that we have to return to the history of this schism and unpack this root assumption that motivates and yet at the same time makes working across the sciences and humanities so problematic.

There are other problems to consider. For instance, people tend to conflate science and technology and the purely visual arts tend to dominate the SEAD discussion (Roger Malina, pers. com.). There is also the problem of the competing plethora of terms and initiatives for cross-disciplinary interactions, be they interdisciplinary, multidisciplinary, paradisciplinary, transdisciplinary and most recently antidisciplinary. The transdisciplinary axiom is clarified in Blasnigg and Punt's White Paper and amounts to this: if SEAD activities cannot contribute to each component of whichever disciplinary collaborations are involved in a fundamental manner that does not compromise their disciplinary integrities, then they are technically not transdisciplinary (also see Punt 2010). Too often it is either explicitly or implicitly proposed that the justification for moving from STEM to STEAM is that art can advance basic science and bridge the "two culture" divide. That being said, there is clearly a generative interaction between art and design, technology and engineering, and there is clear evidence for the productivity for combining basic research in music and science to their mutual enhancement. Yet, for all the interdisciplinary activity in art and science, the results for many commentators despite their proclivity for the collaborative potentials are so far not encouraging (Pepperell 2011, 268).

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[3] The extensive literature on the relationships between the arts, humanities and science is too vast to comment upon in this context, but for a snapshot of views across time, see Bork (2007), Clarke and Rossini (2011), Kepes (1965), Labinger (2011), Milburne (2011), Pepperell (2011), Roof (2011) and Ruskin (1872).

Critical Comments on Select Papers

I begin, if very briefly, with the Root-Bernstein White Paper on the importance of a persistent education in the arts and crafts and the references therein as it serves well as a guiding theoretical base for SEAD (also see Root-Bernstein 1995, 2000, 2001, and Root-Bernstein et al. 2008). This paper is also important for my purposes as Root-Bernstein clarifies the systemic need to distinguish between transdisciplinary processes and disciplinary products (Root-Bernstein 2003, 268). In essence, the White Papers I have chosen to discuss further below confirm Root-Bernstein's definitive discussion on how "the ways in which artists and scientists discover and invent problems, experiment with them, and generate and test possible solutions is universal" (ibid.). They constitute primary documents for any SEAD collaboration particularly as concerns the relevance of the arts and humanities to the sciences, technology engineering, math (STEM) and thus the move to sciences, technology, engineering, arts and math (STEAM), and, ultimately to include the humanities (THEMAS).

Batson's paper, "Ex-scribing the Choreographic Mind" is important on many levels, beginning with the fact that it introduces us to ten years of art-sci lab practice in the investigation of "choreographic cognition" and "the embodied mind." Batson notes that the "cognitive processes generated in dance making" offer "tangible benefits" to science and medicine and have proven and significant outcomes. She points to Edwards (2011) to substantiate the claim that art-sci collaborations are leading twenty-first century research and pedagogy. Referring to DeLahunta (2004), Batson adds that in physicalizing thought dance generates problems and problem solving. This provides "new ways of conceptualizing the inter-relationship of thought and motor skills" and allows for practice-led research with new materials and technologies at centers for cognitive neuroscience which concern theoretical issues in neuroscience, phenomenology, and human movement science. Such cross-disciplinary work clearly offers exciting possibilities but academic rigor should require far more systematic and careful documentation of evidence of what such a ten-year project has produced.

Despite their obvious importance, the problem is that a few of these SEAD White Papers provide any evidence, outside of using citations, to substantiate their claims. Far too many of them are merely rhetorical exercises. In Batson's case for instance, though results are claimed for specific projects, they are not provided nor are any relevant references for them cited. In the case of the Freemantle paper on the British Heart Foundation's art-sci project, the evidence for the value of art to science and thus the collaborative value of such a project to a medical research institution is so scant as to raise serious concerns. Nevertheless, Freemantle retains tenacious commitment to the principle and the ultimate potential values of art-sci work. To highlight this manifest

problem, consider the one instance illustrative as to the contrary: Kuhn's paper, "Thinking with Things: Feeling our Way Into STEM," which addresses mathematics and craft

Kuhn's White Paper provides a fascinating example of the value of art-sci projects for math education using object- and practice-based enquiry. It has enormous potential as a model of an art-sci math project precisely because it bridges two domains few would ever imagine could be so usefully connected - the art of crotchet and higher-order math. Kuhn's paper is also instructive as she provides a case study of how the fear of science, in this case mathematics, inhibits learning. Her paper is exemplary in demonstrating how one of the most important functions of sci-art SEAD projects is to provide contexts, materials and methods for overcoming this problem. Fear is a critical limiting factor for the advancement of science. Fear often prevents young people from engaging and entering science. In essence, this and the other papers do not so much advance basic science as science education. In the long run however this advances science itself through broadening the potential pool of scientists and bringing in creative individuals who might not have ever entered the world of science. Beyond that, the creativity in this and all these papers has a major potential catalytic function.

From my perspective Sarah Kuhn's paper is essential for its pedagogical importance and more generally the nature of the extensive and her Suggested Actions. Set in the context of a fascinating conjunction in hyperbolic crotchet, Kuhn provides a compellingly brief discussion on the "useful arts" and common cognitive developmental roots of art and science. In terms of "Thinking with Things" and "Objects for Enquiry," Kuhn refers to Silver and Ozin's Periodic Table of Nanomaterials and Tatar's Sowed Circuits. These expand the case for how learners of all ages can benefit from working with concrete objects and images or visual and sonified data rather than concepts, as is traditionally the case. And as she notes, "The history of STEM fields is full of examples where discoveries were sparked by objects and images, not just abstract reasoning." Yet to substantiate such claims, the evidence and not just the claim or citation for the said evidence must be provided. In Kuhn's case, the evidence is that Richard Feynman's mother was a Frobelian. This suggests that Feyman's visual approaches to solving math problems, to seeing mathematical relations in terms of patterns, must have been informed by his early childhood experience.

I do not doubt or contest the connection. But as someone with a scientific training I imagine that NSF proposal evaluators would prefer to have stronger evidence for the claim. Fortunately, in this case Kuhn clearly states that though the evidence is circumstantial, the inspirational relation obvious. This kind of clarity would enhance the critical value of all such White Papers to the SEAD project in terms of the persuasive power they could have for the NSF scientific

community which after all often includes artists, designers and musicians. . In future SEAD network discussions and papers, the criteria of evidence-based claims should be clarified. [4] Research needs to be conducted in order to assess the significance of the papers and particularly the justifications for the individual Suggested Actions.

Finally, in a SEAD paper on neuroscience, Cynthia Wagoner and Robert Wilkins consider Ubeats as a model for learning science and music. Involving collaborations with musicians, it alerts one to the fact that NSF grants have been made in the past for sci-art projects. While the Universal BioMusic Education Achievement Tier in Science is thus a critical model for art-science interaction and while many of the authors propose standardization for the purpose of measurement and evaluation of SEAD-type projects, some might question these efforts in that direction. Will they not constrain the creative quest whether or not they are effective at measuring learning? Would it not lead to something like DBAE (Discipline-Based Art Education, see Parsons and Blocker 1993) or some form of multiplex SEAD Standard Achievement Testing and statistical analysis. Such measures are all well and good for justifying and monitoring state and federal programming and perhaps measuring the effectiveness of art-sci projects but do they serve the creative logic of why there should be an "A"in SEAD? Being a proponent of practice-based application, I prefer the outcomes-based achievement criteria rather than assessment. Nevertheless, many of the papers advocate for the former approach and in my paper with Kitto, Kostis, Long, and Trenshaw we have also emphasized standardized testing to evaluate the pedagogical effectiveness of such proposed SEAD projects.

Scott Gresham-Lancaster adds to these fascinating SEAD Network papers on music, sound, and dance in terms of data sonification, a rapidly emerging field for design and research in the context of art-sci collaborations. He notes that in the combined use of both sonic and visual analysis, the synthesis "increases the likelihood of exposure of new features and interconnections hidden in more standard 'visual only' modes of investigation." Here though sonification is a new tool for scientific discovery, it is too early to tell what it might or might not lead to. He makes the important qualification that sonic collaborations have to be carefully orchestrated over time to create functional and aesthetically pleasing results that are self-explanatory and can transcend the data. Similarly in Essle's paper on mobile music and education, we see further evidence of exciting developments in this domain of art-sci activity. Though Essle's project contributes to computer science and obviously has significant value for technologically assisted education, again, the fundamental problem is that no evidence for the advancement of basic science per se is given. In contrast, Braasch's White Paper, "Creative AI Agents for the Arts", brief as it is at two

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4 See Lévy-Leblond, La science (n')e(s)t (pas) l'art (2010) and Roger Malina's response, "Curiosity, Borders of the Real and Multiple Futures" (2011).

pages, is exemplary in terms of the specific deliverables it proposes and the action plans for precise research ends. This is the specificity that scientists would want to see in all these papers in terms of the clarity of the obstacles and the goals to be achieved.

Onfescu's White Paper, "The Nano Art 21 Project" is of special relevance across the board for its clarity of language and purpose. Onfescu's project is also interesting because it proposes a global program. It situates nanoart as a conjoined aesthetic and scientific activity and showcases the collaborative work at Future Lab at UCLA and LACMA. Yet the two projects that Onfescu notes as having delivered "new scientific innovations" in the 1990's, namely Interval and PARC (at Xerox), were discontinued despite having both patented innovations. What were these innovations and patents? Why were these programs discontinued if they were successful in these critical dimensions of measurement and evaluation? Fortunately, Michael Naimark's Leonardo report, Technology-Based Art and the Dynamics of Sustainability" provides such data. But in Onfescu's case, clarification is required given the contradiction between the title of this report and the lack of sustainability of the two projects at Interval and PARC.

Such critical analysis of said evidence-based assertions is essential given Onfescu's conclusion. There he states, "art projects in a research environment will stimulate the researchers adding aesthetic and emotional value to the scientific work, will provide grounds for developing new skills, and lead to new discoveries." The claim is explicit: new scientific discoveries will result as a consequence of SEAD funding. To substantiate this rhetorical assertion we need to know exactly what were the relevant innovations and patents so as to be able to assess their importance and thus justify the claim. If Xerox had concluded that the PARC program had been of generative value to science and technology, would it have discontinued the project? Onfescu concludes by noting that in the future NanoArt 21 will shift its focus to education. And there, as for the value of art to science in the illustrative sphere, the synergies are already well established (see Ursyn 2012). In the end, it is the argument for improving science education, science outreach, engineering and creative illustration that provides the strongest logic for NSF funding of the SEAD mandate.

Arguably the strongest White Paper on all levels, especially pedagogy, application and programmatic outcome-based collaborative project planning is Fishwick's "Learning Computing through Game Experiences". His basic principle is that learners should be enticed into participation through something which they find relevant and interesting. There, the most successful experiences draw upon pre-existing cultural forms. In this case, gaming culture provides a "curricular vehicle for introducing learning objectives."

While Fishwick's paper has strengths in several domains, its power lies above all in its precision of achievable goals and its use of language. For instance, he introduces the notion of leverage. This term has fundamental value as a basic concept for these SEAD White Papers project proposals as a guiding principle in the Suggested Actions. As he writes, the idea behind learning computing through gaming is "to leverage game-based social networks, culture, and gameplay as a means for introducing computing concepts . . ." namely iteration, branching, and recursion and object orientation. Moreover he also provides explicit goals for the different audiences in his Suggested Actions. These are to connect, combine and integrate subjects in a way that allows the computer science students to learn about the above concepts, as well as about alogrithms and automation. For humanities students, the goal is to advance their skills in narrative analysis and critique. For artists, it is to create new sensory experiences. Lastly, the applicability and established rather than proposed practice, is obvious. Most compelling of all, Fishwick has taught a class on "aesthetic computing" for a decade now. Perhaps one day, if not somewhere already, there will be classes being taught on "aesthetic approaches to biochemistry," or conjoined classes on "aesthetic biology" and "aesthetic math."

Fishwick's paper also alerts us to the importance of regional innovation centers for SEAD, in this case the Transtech ATEC Center Hub at the University of Texas at Dallas. Each of these centers has particular strengths and some regional hubs complement others interests as in the case of embodiment. Perhaps UTD ATEC's strongest potential lies in its cross-cutting collaborative structures and programs with multiple institutions in the Research Triangle in North Carolina. There is considerable opportunity at hand for better understanding the connections between cognitive process and the body, specifically embodied learning (Hahn 2007). Pointing us in such directions, Fishwick concludes with two fascinating questions and opportunities. First he asks: To what extent do metaphors involving gestures and body sensations (movement, orientation, tactile sensation and sound) embed themselves in the artificial artifacts found in computing? We could ask similar questions for our representations of atoms and molecules and process in a more highly process oriented vision of biochemistry. Second he asks: What are the thought processes underlying modular coding, conditional branching, and understanding large scale, complex data structures? The very same question could be asked of molecular structures and processes and the large-scale complex data involved in stochastic and synergistic biochemical reactions.

The Fishwick paper stands out as it provides the most sophisticated example of a bridge between technical and humanist language in the art-science SEAD challenge. Noting that disciplinary pedagogy is typically script-based, he emphasizes the alternative value of audio-visual learning as an explicit project to overcome a "crisis of representation." Adding to Kuhn's shift to the visual from the abstract, he asks two vital questions: 1. "Can the humanist's rhetorical mandate

employ audiovisual artifacts?" and 2. Could criticism "be defined by perceptually enabled interaction?"

Fishwick is on the cutting edge. For instance, he asks, "Where embodiment does play a role in cognition connected with these software artifacts, new forms of representation will be required to leverage and capitalize upon the embodiment hypothesis". Going even further, and most interesting of all, consider the potential for this: "Game environments provide excellent breeding ground for the human subject experiments as well as contributing highly sensory embodied experiences." Continuing in this vein, the White Paper by Carol Davis "Smart Games and Tools: Using Immersive 3D Cloning Technology" demonstrates that there are strong potential synergistic relations across sub-sets of the SEAD papers. While the Davis paper complements Fishwick's well, and a more extended meta-analysis elucidating common ideas and goals in such grouped White Papers could clarify this point, it is more practical for the purpose of brevity to recall Root-Bernstein's paper. It has a fundamental relevance and application across the board. In particular, it provides a range of materials relevant to the central issue in this particular meta-analysis – Can art advance science?

To emphasize the relevance and ongoing importance of this critical issue to these papers, Cohen's paper "Bridging the Divide" is especially useful in terms of institutionalization of the art-sci nexus. It describes the establishment and the aims of the MA in Arts and Science at the Central Saint Martins (CSM) and University of the Arts London the city being an all-important context for art-sci projects and exhibitions. [5] Cohen's second Suggested Action is to enable the exchange of ideas that could "lead to the development of new ideas, technologies and applications." Again, not without reason, we are back to instrumentalism and outcomes-based justification.

Also in the United Kingdom, to return to Freemantle's paper, the British Heart Foundation's continuing art-sci program and its expansion into a proposed doctoral program will be of equal interest to follow up on, particularly considering that no single participating scientist at the BHF responded to the survey intended to assess the previous program. A critical reader of that paper would I suspect immediately question whether there might be something else behind the 100 percent failure rate in assessing the Sci in the SciArt project, rather than the Director's seemingly tongue-in-cheek explanation that it was due to an unwillingness among scientists to respond to online assessment requests.

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5 See "A Nervous Encounter." 2013. University of the Arts London Central Saint Martins and the Medical Research Council, Institute of Neuropharmacology, Oxford, http://blog.nervousencounter.com/

Perhaps the take-away point here is that SEAD projects clearly have enormous transdisciplinary potential. But any claims that engaging the arts can directly result in innovations and advances in basic science should either be expressed in the most qualified indirect and potential fashion or evidence should be provided rather than mere rhetoric and reference as is currently the case in these SEAD White Papers and in previous art-sci work (Ione 2003, Mitchel Inouye and Blumenthal 2003). Finally though I barely mention the term "engineering" in this meta-analysis, I imagine that the arts can and do contribute to this field. By way of concluding this first part of the essay and expanding this discussion toward considering the "two cultures" problem in the final part of this meta-analysis, I close with five concerns that these papers raise in my mind.

First and foremost, it seems to me that for any participant in the SEAD network discussion to overemphasize a transdisciplinary agenda without considering the logic and ramifications for the White Papers as a whole is problematic. There is a significant diversity of languages and frameworks being used by different authors particularly as regards the terms interdisciplinary, multidisciplinary, and even paradisciplinary. Each seems to be attempting to use the SEAD Initiative as a context for self-validation and centrality.

Second, the preponderance of evidence from these papers and the relevant reports unfortunately seems to be that art does not directly advance basic science, as reluctant as we might be to accept this conclusion. Yet this does not undermine the fact that cross-disciplinary work can and does contribute to scientific creativity and science education. For those in the transdisciplinary circuit, in terms of the most basic and direct criteria, SEAD cannot be a trans-disciplinary project because it has not been demonstrated that the arts can contribute to basic science. Or have they (see Clarke and Rossini 2011)? Towards future debate and "proof" for whom that matters, it seems then that not only is clarity required on the nature of how each discipline will enhance knowledge and practice in the other, but perhaps some basic research should be conducted to look into this transdisciplinary dilemma more closely.

Third, the difference between the nature and the quality of the papers and evidence-based Suggested Actions between those led by or collaborating with scientists and the non-scientists is so striking that it raises a red flag concerning SEAD. Polemical calls for funding by NSF at the behest of nonscientists is unlikely to be persuasive. For seeking any future funding from scientific organizations, the tactic of pushing the transdisciplinary agenda as a theoretical base should perhaps be seriously addressed if indeed it is the case that the arts have not been proven to advance basic science.

Fourth, in spite of these critical preliminary and guiding issues stated so starkly, the White Papers clearly show long-standing and emergent evidence of SEAD activity. Accordingly, a national program with cross-cutting state- and regional-level projects is logical in that there is a securely established evidential and institutional base. SEAD is obviously ready for synergistic leveraging. As a platform for the advancement of science and its relation to all other disciplines it could also serve to overcome the persistent public misconceptions of science and what constitutes science.

And finally fifth, should the argument that the arts can advance basic science be avoided? If it is to be included in any White Paper, should it rather not be carefully qualified and redirected in terms of the use value of the arts for science education, for engaging the public in better understanding and appreciating science, for improving science's public image and for enhancing scientific sensibility through artistic creativity?

A Meta-Discussion in Historical Perspective: Cautionary Comments

In essence, across the board the SEAD Suggested Actions are action plans for overcoming the institutional and social reality of two perceived separate cultures. Yet, it is striking how the same issues that all these SEAD papers address were issues of special concern to the NSF 50 years ago. And while there is evidence of significant change, the fundamental issues and challenge appear to remain the same. With that continuing dilemma in mind, this meta-analysis is a meta-critique in that it critically comments upon the root assumptions behind almost all these papers. There are however notable exceptions, such as the papers by Root-Bernstein and Fishwick and others I have highlighted here as exemplary.

As Root-Bernstein's important paper and his larger work underlying it demonstrate conclusively, the reality is that the more successful a scientist is, the more likely he or she is to have a life-time engagement with the arts in terms of a persistent disciplined practice. It is the attention to discipline, detail, and aesthetics that unites and feeds both domains. This reality of the generative importance of artistic experience in many scientists' lives is so obvious and so well known (especially to many an NSF scientist) as to raise again a major red flag over too many of the papers. They assume that the "two cultures" perception of reality is an axiomatic truth and an obstacle for SEAD to overcome.

Major problems exist regarding disciplinary barriers in the educational system. All the Suggested Actions work towards ameliorating these problems. They are unrealistic (being visionary) for large-scale pedagogical and curricular transformation at the school, district, state, and national

levels. However, if funded as smaller and subsequently scalable germinal initiatives, they could well take root and grow over time by force of productivity and inspiration in the same manner as the scientist/educator Froebel achieved with the kindergarten concept. In that, this meta-analysis considers the specific projects and programs proposed at the following innovation centers— namely at UTD, UCA/CSM, DXART, SARC and the BHF—to be exemplary. They have clearly defined, relatively limited and wholly achievable objectives. On the other hand, the BHF and UCA/CSM projects perfectly exemplify the established challenge for art-sci projects in the United Kingdom, a particular subject of concern addressed below. The issue is simple: can art advance basic science?

These papers return us to C. P Snow's highly inaccurate and unnecessarily divisive notion of "two cultures". Snow's polemic, though well intended, was based on grossly simplified stereotypes and contexts and fostered a radical misunderstanding of science by non-scientists. The unfortunate situation we face is that the public, and many academics and artists are convinced of its truth value. Moreover there is another problem that while scientists if sufficiently intellectually and artistically oriented can easily engage art and social science with the requisite effort, it is very difficult for an artist or nonscientist to be able to seriously engage science. Any collaborative proposals have to keep this problem foremost in mind.

In effect, through these White Papers the SEAD network is gathering into the same context participants with wholly different notions of what constitutes science and scientific data, as well as who has the right to make that determination. This is extremely dangerous for scientists and should be very carefully addressed. At the same time it is perfectly true that the rigors of science, the peer review system, and the professional system as it exists radically constrains more creative work above and beyond "normal" science.[6] Going beyond such truisms and generalities is difficult. It is a challenge that requires nuance and complexity. Fortunately, a good many of these papers do so precisely because they are proposed by scientists.

Another reason why it perhaps should be explicitly addressed, is that C. P. Snow's reactionary and simplistic idea un-reflexively informs the fundamental logic of far too many of these papers, whether it is or is not a reality in most people's minds (and in lives). The fact that Snow's divide has established such a powerful presence even in the imagination of those social scientists who should have known better, had they given proper attention to the original paper and the critique of it at Cambridge at that time, is extraordinary.[7] Taking Richard Dawkins's notion of the

6 As for the problem of the politicization of NSF funding, see Megan Tracey, "NSF, Peer Review and Debates over Congressional Oversight", *Anthropology News*, July/August 2013, 17.
7 See for instance, James Elkins, 2008.

"meme" as an example of the affective life and evolution of a concept (1976), we see that the cartoon-like perception of science and scientists as wholly Other, as separate from the world, not only continues as a dominant idea in popular culture but potentially sets the base for SEAD science programs if not directly addressed.

It is important then to note that this idea is becoming increasingly pervasive. It also holds true in the minds of those scientists whose ever-narrowing training and experience may have led them into sterile territory in which the arts and humanities, the philosophy and history of science are topics that are considered to be of no practical or theoretical consequence to their work. These SEAD White Papers should address this. It should be taken as axiomatic in the science community, and in the public at large, that a scientist has a vastly higher chance of making major contributions to the advancement of science and becoming a Nobel laureate if she or he is a practicing artist, particularly a musician (Root-Bernstein et. al. 2008). Briefly, the fact that involvement in an artistic endeavor increases the entire tenor of a person's life in terms of the quality of their work and their intellectual life—and, for those inclined, their spiritual development—is well known across cultures and throughout history. It completely negates Snow's thesis.

The Science/Culture Schism

The notion of a cultural "schism" was so pronounced in the late 1950s that the National Academy of the Arts and Sciences was given a grant by the NSF in 1963 to investigate the relationship between the sciences and the arts as well as between the social sciences and humanities. The goal was to examine the connections and relations between these fields and to reflect upon their methodological differences and how and if they were affecting each other. Anthropologists and art historians figured prominently in that project, and The National Academy duly published the results in a special issue of Daedalus titled "Science and Culture" published in 1965. That study is of extraordinary relevance to SEAD today because the editors' intent was to investigate just how accurate "the constant repetition of the idea of a 'schism'" was at that time.

The anthropological notion of schismogenesis effectively describes this cultural process of specialization and separation far better than Snow's popular simplification (Bateson 1935). As Bateson defined it, schismogenesis is "a process of differentiation in the norms of individual behavior resulting from cumulative interaction between individuals" or in our case professional groups (Bateson 1958, 175). In essence, I am proposing here that American anthropology offers

the most appropriate assessment ground for taking into account the long history of interdisciplinary research and its practical application.

The popular idea that the sciences and the non-sciences were working in isolation and that those in one domain did not understand what was going on in the others is clearly a tenacious one. Unfortunately, almost all of the SEAD papers uncritically recapitulate this notion of "two cultures"—the scientists versus the rest. This is why I emphasize Root-Bernstein's work as foundational. It effectively bridges the divide without reducing the irreducible disciplinary differences. In any event, this deeply flawed axiom runs through the papers virtually as a matter of faith. Thus C. P. Snow's foundational lecture at Cambridge has clearly directly or indirectly informed all these papers, whether or not the authors have actually read Snow. Certainly SEAD researchers seem wholly unaware of the fact that the idea was thoroughly pilloried at the time, with such devastating critique that it poses a serious problem to the intellectual integrity of these collected papers. Across the board the SEAD community is un-reflexively recapitulating Snow's dualism.

This deserves attention as there are fundamental differences between science and non-science which require clarity for any such debate over the proposed value of SEAD for the NSF mandate. The problem scientists face in collaborating with nonscientists, particularly artists and the philosophically inclined, is not only a matter of method. Falsifiability and evidence matter. The epistemological reality of measurable observations regardless of principles of uncertainty and relativity matters. It allows us to distinguish between fact and fraud (see Goodstein 2010).

The dangers for SEAD and the potential consequences are nowhere more symptomatic than in the Wellcome Report on the decade-long SciArt project in Britain that lasted from 1996-2006. The report concluded that the collaboration between artists and scientists had not delivered on the initial justification that such collaboration would lead to scientific innovation. The same question must surely be considered for those White Papers that would justify their Suggested Actions on these grounds as it seems an established fact that interdisciplinary initiatives with the arts have not directly contributed to the advancement of basic science itself.

In that context, one must ask: Are the SEAD projects collected here be so different from the UK SciArt project that significant innovation in science and industry and beyond might result? I would argue that the answer is resoundingly yes. SEAD is so much more than art-sci as it was in the UK SciArt project. Many of the practitioners have clearly identifiable material and pedagogical goals in mind. In the final analysis, whether one conceptualizes these SEAD White Papers projects as interdisciplinary, multidisciplinary, trans- or paradisciplinary, the proven

value of such collaborations for science more broadly are not insignificant. They demonstrably enable enhanced public engagement, improve science education and add value in expanding the reach and relevance of each discipline to another, as well as internally across specializations within disciplines.

To return then to the 1965 NSF Report, consider Edmund Leach's comment: "As the category distinction scientist/non-scientist becomes more sharply defined, there is feedback into cultural behavior; the scientist takes pride in the exclusive incomprehensibility of his activities, so that the group to which he belongs takes on for him many of the attributes of a religious sect" (Leach 1965, 33). Showing how "we groups" exist in every social system, he takes the cult analogy further by commenting on specialization being a function of dynamic sect formation over points of dogma in which sectarian groups are innately conservative and transmit basic principles of belief over time through actively indoctrinating recruits. Individuals use different vocabularies depending on their context and group membership, and in the case of scientists, "each small group of technical experts feels impelled to create its own special jargon language which makes its esoteric activities quite unintelligible to everyone else." (32).

Renee Dubos states that the "two cultures" may be an illusion, but in practice science is still regarded in our communities as a kind of foreign God, powerful and useful yes, but so mysterious that it is feared rather than known and loved" (1965, 228). Dubos adds that the root cause of the hostility to science at that time among the youth and the fall in the number of students entering the sciences was a matter of anxiety (229). Dubos noted that though there had been much debate over a lack of communication between the sciences and humanities, the "disjunction is not as critical as is often suggested" and can be addressed through a common language based in the senses or images (238). He calls on specialists to return to basics in order to communicate with society at large. We are then back to Root-Bernstein and the guiding principle underlying all these SEAD White Papers, to bridge the divides without compromising the integrity and advancement of each discipline.

The SEAD papers project a desire to engage science so as to increase communication about science. Yet I see little or no evidence that any of the SEAD papers here can or do demonstrate scientific advances except perhaps for Kuhn's case. What they all do is show how strong the desire is by so many scientists, engineers, artists, and others to collaborate across their respective disciplinary specializations. Whether it be in computer gaming, nanotechnology, music, biology, neurochemistry, or dance, they each exhibit a turn to the senses and an overwhelming commitment to education that ameliorates the antipathy to science. Collectively then, all of the

Suggested Actions, at least for these 15 papers I discuss, have a basic purpose of enhancing science education and its application through collaborative cross-disciplinary activity.

Conclusion: Cautionary Observations from the UK SciArt Project

A cautionary note might be useful in line with the above observations and comments. In Europe and the United Kingdom, sci-art projects and SEAD-type initiatives are far ahead of those in the United States. In the best-known case, the Wellcome Project in the United Kingdom, the cautionary advice for proposing any such projects in the future from the perspective of science is very clear. [8]

The stated purpose of the Wellcome Project was to advance innovation and creativity in science through art. The evidence presented in the report does not support these rhetorical claims. One critical participant interviewed noted that it was dangerous to assert that the artists had encouraged the scientists to be significantly more creative and specifically stated that these claims were merely rhetorical (Glinkowski and Bamford, 2009). It is not so much that it is dangerous for science, being a known fallacy in the UK SciArt Project. It is dangerous for those who would argue that this should be the reason for funding art-science collaborations and by extension, SEAD. However, it is most certainly the case that the arts can enhance science education and communication about science to society - never mind indirectly inspire scientific minds.

Ultimately, the Wellcome Report shows how pernicious and ill-informed is the two cultures" stereotype. Is the world really divided into scientists and the non-scientists? It is not that there is no truth in the difference between the way scientists work and reason or in the professional and institutional divide; the problem lies in the idea that scientists are not creative, do not take risks, cannot effectively communicate their results, and do not have any interest in the arts. Consider one artist interviewed who first asks: "What could be more 'other' than a group of scientists at work?" Later the artist modified this saying, "I realized that scientists could actually be excellent communications, and very approachable . . . . wonderful collaborators and spurrers-on of ideas." (Glinkowski and Bamford 2009, 65). Other comments in the report are even more telling: "They (scientists) are human and they don't want to spend their life churning out papers, they want to find some meaning in what they are doing" (67). Or consider this: "Normally, our sense of scientists is that they are very dour people." Scientists are seen by such artists it seems virtually as aliens. They are considered to be unhappy, repressed, and unfulfilled. Yet as one artist learned along the way, "Scientists are conflicted, ambivalent; they describe how they do their science in

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8 For the Wellcome Trust's own analysis of the project, see Glinkowski and Bamford (2009).

a strict way, but when you probe more they begin to soften around the edges, and you find that art is being used by the scientists to help them understand some of their ambivalences about their professional culture."

Overcoming the above stereotypes, and the idea that scientists might be any more ambivalent than anyone else about their lives and work, the Wellcome ArtSci project did note that a very few UK scientists were profoundly positively affected by their collaborations. Their science itself was not affected, but their sense of the importance of bringing their work to the public and in some cases an awakening need to explore their creative interests. This is all well and good but these scientists were few and far between and we do not know anything about those who did not respond and why. The fundamental problem is that the said evidence of the usefulness for science is grossly inflated in the report. The only demonstrated instance of innovation was in a pathology laboratory in which the presence of the artist resulted in the use of more colorful stains. Yet the report builds upon this as: "SciArt projects were felt to have evidenced a range of type of innovations across the arts and sciences and at a technical as well as at a conceptual level." The claim was modified, however, as such: "It didn't affect the science per se, but it affected the way that it was delivered." (Glinkowski and Bamford 2009, 57).

I emphasize this rather harsh judgment as a precaution on two levels. First none of the SEAD White Papers, except in some sense for Kuhn's work on hyperbolic planes, have provided evidence that the collaborations have made or can make proven contributions to science. It is all in the realm of rhetoric and thus a very dangerous proposition considering the demonstrated failure of art to directly contribute to science. As problematic, almost to a paper they recapitulate the "two cultures" axiom as an article of faith. Leading on from that axiom, they almost uniformly propose that overcoming the "two cultures" divide is the essential practical function of the goals to be achieved through the Suggested Actions.

In the humanities and social sciences, efforts to overcome the crisis of scriptural representation have been building up steam since the post-modern era and the turn to the sensory dimension in the 1980's. At this point we have emerging fields such as sound studies, sonic anthropology, acoustemology, these being outcomes of the movement to embodiment in the social sciences. In fact, research on typical SEAD questions has been going on in anthropology and allied disciplines, in art, neuroscience, dance, musicology and ethnomusicology since the 1960s.[9] In order to ameliorate these shortcomings, as to what is new or not, and what might be achieved or has already been achieved, never mind the "two cultures" conundrum, SEAD might need to more effectively engage such large academic audiences (including engineering and architecture) in

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9 See *Science and Culture*, *Daedalus* (Journal of the American Academy of Arts and Sciences), Winter 1965.

more targeted ways than this open initial call which has resulted in this emergent network as it currently exists.

My concern as someone with both a scientific training and research experience is that basic principles of science should not be compromised by collaborations with non-scientists. The non-scientists too often do not sufficiently appreciate the nature of data and the fundamental importance of falsifiability. This is where the danger lies. For myself, even though I am a social scientist trained during the post-modern art era, when entering into a discussion such as this as it concerns potential funding, I maintain that one principle has to be established a priori. If one claims that one's project should be funded because it is going to advance basic science, one had better be able to prove it. With all that in mind, and returning to the first part of this meta-analysis on subsets of the White Papers, if one examines the Suggested Actions in those and all the papers what could we conclude on the basis of general principles applicable to all?

Perhaps the conclusions could be as follows:

1. Cross-disciplinary research and teaching is important because it allows scientists and specialists working in one field or sub-field to cross-fertilize methods and techniques and information with others;

2. The arts undeniably help science and engineering for the purpose of education and public communication of scientific knowledge;

3. All are enriched by collaboration in different and complex ways;

4. We should not reduce the entire complex equation to whether it advances science or not because the gains are demonstrably exciting across the disciplines as can be seen in all of these White Papers. They are not only exciting pedagogically. As Fishwick's paper proposes, they may have potentially significant outcomes for the understanding of and consequences for embodied learning, and they have demonstrated capacity for product development and design.

The Suggested Actions in these White Papers should perhaps be approached with caution in terms of the fact that the failure of the UK SciArt project to deliver on its initial logic has left a "residual skepticism" (Glinkowski and Bamford 2009, 72). And yet SciArt has certainly taken off in Europe and the US and the UK scientists interviewed, though it was only a small sample, were "positive about the value of SciArt and its benefit" (71). Clarifying this distinction, one respondent noted, "I don't think that artists really challenge the scientists scientifically, but I

think they challenge them about the purpose of their science and raise questions about different ways there might be of looking at their science and presenting the outcomes" (70). Therein, the collaborative experience allowed the scientists to take a more historical perspective on their work and to better appreciate "the heuristic limits that constrained their habits and practices of thinking." (70). For these reasons and more, STEAM, SEAD and THEMAS projects are fundamentally exciting. Nowhere does this have more potential than in applied projects that offer specific material goals linked to technology and education.

Bibliography

American Academy of Arts and Sciences. 1965. Proceedings 94: 1 (Winter).

Bateson, Gregory. 1958. *Naven: The Culture of the Iatmul People of New Guinea as Revealed Through a Study of the "Naven" Ceremonial*. 2nd. ed. Stanford, CA: Stanford University Press.

———. 1935. "Shismogenesis." Man 199.

Borke, Robert O. 2007. "Art, Science and Evolution." In Elizabeth Mansfield, ed., *Making Art History: A Changing Discipline and its Institutions,* 187-201. New York: Routledge.

Clarke. Bruce and Manuela Rossini, eds., 2011. *Routledge Companion to Literature and Science*, 287-97. London: Routledge.

Dawkings, Richard. 1976. *The Selfish Gene*. New York: Oxford University Press.

DeLahunta, Scott. 2005. "SeparateSpaces: Some Cognitive Dimensions of Movement. http://diffusion.org.uk/species_of_spaces/D_SOS_Delahunta_A4.pdf

Dubos, Renee. 1965. "Science and Man's Nature." Daedalus, 4, 1, 223-44.

Elkins, James. 2008. *Six Stories from the End of Representation: Images in Painting, Photography, Astronomy, Microscopy, Particle Physics, and Quantum Mechanics*, 1980-2000. Stanford, CA: Stanford University Press, 2008.

Glinkowski, Paul, and Anne Bamford. 2009. "Insight and Exchange: An Evaluation of the Wellcome Trust's Sciart programme." London: Wellcome Trust. http://www.wellcome.ac.uk/sciartevaluation

Goodstein, David. 2010. *Fact and Fraud: Cautionary Tales from the Front Lines of Science*. Princeton: Princeton University Press.

Hahn, Tomie. *Sensational Knowledge: Embodying Culture through Japanese Dance*. Middletown, CT: Wesleyan University Press, 2007.

Ione, Amy. 2003. "Conference Review. ArtSci 2002: New Dimensions in Collaboration, December 6-8." Leonardo Digital Reviews, January.

Kepes, Gyorgy. 1965. "The Visual Arts and the Sciences: A Proposal for Collaboration." Daedalus, 17-134.

Klahr, David. 2002. *Exploring Science: The Cognition and Development of Discovery Processes.* Cambridge, MA: MIT Press.

Labinger, Jay. 2011. "Chemistry." In Bruce Clarke and Manuela Rossini, eds., Routledge Companion to Literature and Science, 51-62. London: Routledge.

Leach, Edmund. 1965. "Culture and Social Cohesion: An Anthropologist's View." Daedalus, 24-38.

Leavis, F. R. 1962. *Two Cultures? The Significance of C. P. Snow*. London: Chatto and Windus.

Lévy-Leblond, J.-M. 2010. La science (n')e(s)t (pas) l'art: Brèves rencontres. Hermann, Paris.

Malina, Roger. 2011. "Non-Euclidian Translation: Crossing the River Delta from the Arts to the Sciences and Back Again." Leonardo 1: 3, ix-xi.

———. 2011b. "Curiosity, Borders of the Real and Multiple Futures." Leonardo 1: 4, ix-xi.

Milburne, Colin. 2011. "Nanotechnology." In Bruce Clarke and Manuela Rossini, eds., *Routledge Companion to Literature and Science*, 181-91. London: Routledge.

Mitchell, William J., Alan S. Inouye, and Martyn S. Blumenthal, eds. 2003. *Beyond Productivity: Information Technology, Innovation, and Creativity*. Washington, DC: The National Academies Press.

Naimark, Michael. 2003. "Truth, Beauty, Freedom, and Money: Technology-Based Art and the Dynamics of Sustainability." A report for Leonardo Journal supported by the Rockefeller Foundation.

Parsons, Michael J. and H. Gene Blocker. 1993. *Aesthetics and Education: Disciplines in Art Education: Contexts of Understanding*. Urbana: University of Illinois Press.

Pepperell, Robert. 2011. "Art Connections." In Bruce Clarke and Manuela Rossini, eds., Routledge Companion to Literature and Science, 264-75. London: Routledge.

Punt, Michael. 2011. "Curiosity, Innovation and Agency." Leonardo 1: 4, vii-viii.

Roof, Judith. "Genetics." In Bruce Clarke and Manuela Rossini, eds., Routledge Companion to Literature and Science, 124-34. London: Routledge, 2011.

Root-Bernstein, Robert. S. 2000. "Art Advances Science." Nature 407, 134.

———. 2001. "Music, Science and Creativity." Leonardo 34, 63-68.

———. 2003. "The Art of Innovation: Polymaths and Universality of the Creative Process." In Larisa V. Shavinina, ed., International Handbook on Innovation, 267-ff. Amsterdam: Elsevier.

Root-Bernstein, Robert. S., and H. Garnier. 1995. "Correlations between Avocation, Ascientific Style, Work Habits and Professional Impact of Scientists." Creativity Research Journal 8, 115-37.

Root-Bernstein, Robert. S., Lindsay Allen, Leighanna Beach, Ragini Bhadula, Justin Fast, Chelsea Hosey, Benjamin Kremkow, Jacqueline Lapp, Kaitlin Lonc, Kendell Pawelec, Abigail Podufaly, Caitlin Russ, Laurie Tennant, Eric Vrtis, and Stacey Weinlander. 2008. "Arts Foster Scientific Success: Avocations of Nobel, National Academy, Royal Society, and Sigma Xi Members." Journal of Psychology, Science, Technology 1(2): 51-63 (2008). http://www.psychologytoday.com/files/attachments/1035/arts-foster-scientific-success.pdf

Ruskin, John. 1866. "War: A Lecture Delivered the Royal Military Academy. Woolwich.

———. 1872. The Eagle's Nest: Ten Lectures on the Relation of Natural Science to Art." London: Smith, Elder and Co.

Sielke, Sabine. 2011. "Biology." In Bruce Clarke and Manuela Rossini, eds., Routledge Companion to Literature and Science, 29-40. London: Routledge.

Siler, Todd. 1990. *Breaking the Mind Barrier*. New York: Touchstone.

Snow, C. P. 1963. *The Two Cultures: And a Second Look*. Cambridge: Cambridge University Press.

Tracey, Megan "NSF, Peer Review and Debates over Congressional Oversight", Anthropology News, July/August 2013, 17.

Ursyn, Anna, ed. 2012. *Biologically Inspired Computing for the Arts: Scientific Data through Graphics*. Hershey, PA: IGI Global.

Yudkin, Michael. 1962. "Sir Charles Snow's Rede Lecture". In F. R. Leavis, Two Cultures? The Significance of C. P. Snow,33-45. London: Chatto and Windus.

Zilberg, Jonathan. 2011. "Beyond the Estuary Metaphor." Leonardo 1: 4, 1-11.

Steps to an Ecology of Networked Knowledge and Innovation: Enabling new forms of collaboration among sciences, engineering, arts, and design

White Papers Abstracts

Education Focus Program [EFP] An Independent Curriculum At Grassroots Level

http://wp.me/P2oVig-fq

Coordinator : Irene Agrivina

EFP is a program carried out by HONF – House Of Natural Fiber, a non-profit organization based in Yogyakarta, Indonesia. Yogyakarta is a unique city that is well known for the cultural and historical heritage and one of the main education city in Indonesia. EFP conducted independently during a period of more than 12 years. The EFP is a curriculum that concentrates on interdisciplinary scientific exchange and collaboration in the critical analysis of issues that arise from existing circumstances. This triggers the processing of innovative ideas to find the best solution for the problems in the society. The EFP mainly aims to build an open mindset and mentality in society by bridging the arts, science and technology through educational activities in a continuous nature that compromise each other.

HONF methodology in implementing EFP to Yogyakarta society is mostly concerned to the needs of cross-collaborative actions responding to technology development and practical use in daily life. Inadequate infrastructure and conditions in Indonesia especially in terms of technological usage and working methods has created innovative responds from the society. Sustainable actions were done to systematically expand or convert accessible technology to be used as multifunctional and cross-functional tools. By working in diversity as a unity, this curriculum try to enrich innovative ideas and creations; enlarge educational scopes in a flexible working methodology. EFP conducted independently in the grassroots level and community base working method. HONF deliberately designed EFP as the main guide in planning and implementing activities that are consistent and sustainable of all a new initiative and focuses on educative activities in the form of; Learning by Sharing, Learning by Exchanging, Learning by Serving, and Learning by Doing.

www.natural-fiber.com

"How to Enable Science/Engineering to Arts & Humanities" or Conversely "Collaborative in Spirit-Only: Keeping an Open Mind on Collaboration Across Disciplines" Or "How to Make a Scientist Run-Like-Hell From an Artist's Collaboration Inquiries"

http://wp.me/P2oVig-8a

Coordinator: Krisanne Baker

I saw your call for papers and it struck me as funny – particularly because as a science-based artist making award-winning work specifically about water quality, availability, and rights for the past seven years, I've yet to find one scientist with whom I would gladly collaborate. Not that I am being picky – I can't afford to be picky – since there are ultimately no takers to my offers of collaboration.

So here's my real life scenario – I presented my work at the Woods Hole Oceanographic Institute through the guise of the Woods Hole Film Festival – my true desire was to talk to people at WHOI and find a collaborator. My film, 'Upstream to Downstream (In Our Bloodstreams)', was shown as a preliminary to the feature film 'Upstream' with the same concept but in lengthy documentary form about Dr. Sandra Steingraber's struggle with early onset cancer and exemplifying my theory of 'what we do upstream matters downstream.' Mission One: Accomplished.

Mission Two
At the finish of our films ensued an empassioned Q & A session; so much so, that after forty minutes, the Q & A was called to a halt by the film festival crew, who needed to wrap things up for the evening. During this period, I made a plea:
"I'm not just some crazy artist making films about my paranoias. I am a concerned citizen who values scientific research, and I use it as the basis of, and inspiration for the film you just watched. A long list of foreign chemicals that are ever-present, in municipal drinking waters growing in the past eight years from 33 to close to 300, in babies umbilical cords has been the inspiration for this film. The images I put together hopefully speak to these joint concerns of both scientist and artist. Typically when faced with a science report of data and graphs, people just turn away and won't read them. Are there any scientists in the audience tonight who wish they could put some visuals to their data? So I try to make images that relate these scientific concepts and put them into short digital videos which are self produced. These shorts I see as a public service announcement – or at the longest – an info-mercial – for our Attention Deficit Disorder culture."

Despite incredible conversations and being in the right place at the right time, I'm still finding scientists, even the ones who gave me their cards as potential collaborators, never get back to me after I get home and send a follow-up e-mail inquiry. I mistakenly thought when someone gave their card, that they truly were interested – Mission Two: on hold . . .

I've even resorted to submitting my films to science film festivals to try to gain some credibility with the science community. 'Upstream to Downstream' is currently playing in Australia at the Scinema Festival of Science Film and Conference. So, despite my best efforts of introducing myself and my work and conversing oh-so-knowledgably on the subject at hand, my conclusion is that the people with the data are afraid of the people with the visuals. Let's face it: your time is precious and my time is precious, but as an artist, I'm used to not getting paid for very much for my time. I know, I should have gotten my first degree in Marine Biology, instead of art . . . [sigh].

So here's my funny scenario

Step One:
Show 'em what you got.
Show the visuals that you believe convey some or most of their concerns
[These can be excerpts from your previous or current works in still image or video image format –warning!: steer clear of any piece of art that contains sense of mystery or could be categorized as'probably drug-induced'.]

Step Two:
Talk about your paranoias and anxieties that are not conspiracy-therory related
[Make sure not to mention any close relations with therapy ties;
List each concern documenting with a before & after type comparison – scientists might accept these as theorums & results sans controls;
Speaking of out-of-control . . . don't appear passionate . . . try to keep voice monotone]

Step Three:
Invitation to Collaborate –
[try to keep under your hat the fact that you do all of your work with no outside funding when people find out you do this work for free – they really question your sanity!]

Offer to put their visuals together as a short video documentary, or for the really adventuresome scientist . . . an (gasp) experimental film.
Offer that you are cognizant in presentation formats for potential public broadcasting and internet savvy.

Should the scientist/engineer be without ideas on visuals, offer that you will put together some sample visuals to underscore their data, and then will seek feedback on efficiency of content/content for finalization modifications.
Remind the right-brained crew not to shy away!; that their genius combined with the left-brained crews' visual brilliance may forge new insights in the general populists' minds of our current culture.

So If I don't assume the stereotypical 'dry', 'boring', or 'analytical' about scientists, can I hope they won't assume the 'flighty', 'crazy', or 'unstable' about me? I think we both grew up reading National Geographic . . .

Respectfully submitted with a smirk,
Krisanne Baker, Maine Ecological Artist and Educator
http://www.krisannebaker.com

The Delicate Balance of BlueGreen Algae – the video portion alone of a multimedia presentation based on the little known importance of bluegreen algae as the foundation of our food pyramid 2011

https://vimeo.com/37494201

Upstream to Downstream (In Our Bloodstreams) 2010 – **This is the film I referenced in the abstract 'How to Make a Scientist Run Like Hell . . .'**

https://vimeo.com/14019909

Content Aware Anxieties (with narration) 2012 most recent based on the dangers of fracking

https://vimeo.com/39367788

World Water Cris(e)s: Potential Effects/Cumulative Effects 2009

https://vimeo.com/4430074

The Human Project

Coordinator: Saulo Faria Almeida Barretto; Renata Piazzalunga, Instituto de Pesquisas em Tecnologia e Inovação, Brazil

The Human Project is a proposal for a model of human development for regions with high social and economic vulnerability, based on the relationship between art, science and technology, having culture and environment as cross cutting elements. This model is being deployed by the Instituto de Pesquisas em Tecnologia e Inovação (IPTI) in the municipality of Santa Luzia do Itanhy, one of Brazil's poorest regions, but that holds an important environmental and cultural heritage. In practice, what we do is to apply this art, science and technology relationship in the development of Social Technologies, with focus on education, public health and employment and income improvement (creative economy), basic pillars of the development in such regions, with a systemic and evolutionary perspective.

Social Technologies are defined as "products, techniques and/or re-applicable methodologies developed in the interaction with the community and that represent effective solutions for social transformation". In practice this concept implies an approach to science and technology quite innovative, especially because it puts the community as an active part in the research process and is no longer just mere beneficiary. For it is clear that there are issues related to technology ownership and autonomy, essential for subsequent re-application, which can not be resolved in labs, not from theoretical models.

One of the aspects we observed as very relevant to the application of The Human Project model is that it not only allows the generation of innovative Social Technologies, but also provokes the initiation of innovation in contexts destitute of any apparent possibility. This is due both to the inclusion of a challenging way of construction of thought, in which researchers are motivated to act jointly and interactively with the three main drivers of the THP, and to the possibility of including community members in an effective and active manner in projects through the intuitive knowledge that comes up by means of the stimuli of perception and senses activated by the bias of the aesthetical, always present as a methodological premise in any IPTI interventions. Finally, another relevant aspect of this model is that it is very effective to minimize the difficulties that arise in scientific projects designed to be applied directly in the communities due to the large knowledge gap between the research team and the local people.

However, establishing a relationship between art, science, technology and society runs into several obstacles, starting with the traditional view of the scientific community to think less on issues such as technological appropriation and more on scientific publications and patents that are still essential for the development of any academic career. This is largely due to the way national systems of science and technology evaluate researchers and institutions, always based on scientific production. In the case of Social Technologies, the most significant result should be the number of reapplications, i.e. the number of communities that have adopted the technological innovation, rather then how many scientific papers had being published or conferences attended.

Through the practical results of various projects related to The Human Project we hope to contribute to strengthening the relationship between art, science and technology as a strategy for promoting human development, but also to contribute to a reflection and necessary improvement of the current mechanisms for evaluating the scientific competence of institutions and researchers that better meets the real demands of society.

Ex-Scribing the Choreographic Mind—Dance & Neuroscience in Collaboration

http://wp.me/P2oVig-90

Coordinator: Glenna Batson, PT, ScD, MA, Professor Emeritus (applied), Winston-Salem State University

www.glennabatson.com

Today, one of the most compelling conversations in transdisciplinary discourse is the exchange between dance and neuroscience. Over the last decade, dancers and neuroscientists have come together to create live, synthetic artscience laboratories in which to explore the processes underlying "choreographic cognition" and the embodied mind. Whether creating, performing and viewing dance, complex multi-modal physical and mental processes emerge that manifest as high levels of creative thinking. Cognitive processes generated in dance making have potential benefits that stretch beyond aesthetic aims — practical, social, scientific and medical. Many formal dance-science exchanges and projects occurred, with key choreographers from Europe and Australia, such as William Forsythe (Ballett Frankfurt), Wayne McGregor | Random Dance UK, and Shirley McKechnie and Catherine Stevens, University of Melbourne. Each has generated projects close to home, with research extending several centers for cognitive neuroscience in the US (David Kirsh, University of San Diego and Scott Grafton, University of California at Santa Cruz). These projects have been examples of multi-directional research and creative practice, engaging a wide range of information technology and digital media, with nascent, but significant outcomes. Despite initial momentum, the field remains fragmented. Creative clusters have not advanced theories or methods to evolve a focused discourse. While major funding sources have fertilized the ground beyond the pilot level in Europe, US funding sources have little grasp of the importance of this topic. Although dance affords extensive opportunities for empirical investigation, projects face obstacles, such as constraints on time, access, training, and limitations within technologiges and digital media, as well as an underdeveloped strategic vision, commitment, and cohesion across disciplines, both within and outside of the academy. Several directions are needed to address these obstacles. Alliances need to be forged within educational and cultural institutions to create environments that support dance artists, media/technology designers, and scientists in cross-disciplinary creative research. This includes affording the means of structuring and managing projects; providing open source development and access to new tools of technology and media; providing training to enhance mutual dialogue and project participation; and philosophically and financially supporting creative cultures in local and global initiatives that advance new research methodologies in the synthesis of the art of dance making and the science of cognition.

Transdisciplinarity: Challenges, Approaches and Opportunities at the Cusp of History

http://wp.me/P2oVig-8Q

Coordinators: Dr. Martha Blassnigg, Professor Dr. Michael Punt

Advisors: Professor Roger Malina, Professor Dr. Jan Baetens, Mr. Mark-Paul Meyer, Dr. Martin Zierold

Transdisciplinarity: Challenges, Approaches and Opportunities at the Cusp of History

Until relatively recently science, engineering, art and design each had their own history. Increasingly they are becoming to be understood as components in the broad sweep of the production of knowledge for the good of humankind and the supporting environment. The most convincing evidence of this is in the shift in concern for the immediate and medium-term to the long-term sustainability of the earth as a nurturing environment e.g. approaches to climate change, water resources, holistic science, the socio-political and economic, as a global problem. The recognition of the interrelation and interdependence of hitherto discrete histories as important, asks for new modes of interaction which are more than opportunist, convenient or problem-driven. This calls for more strategic approaches to transdisciplinarity as the organizing principle for research collaboration.

Survey of concerns

In the last couple of decades voiced discussion around the topic in the literature and in practice, which has been spearheaded by Nowotny and Gibbons et al. with a social science focus and by Niculescu et al. with a science and humanities focus. However, there is a growing slack use of the term in the context of collaborations and points to an urgent need to unravel some of the inherent confusions of the meaning and value of transdisciplinarity in the legacy of some of these interventions if the moment is not to be lost. We propose that a robust framework to think and practice transdisciplinarity is to be developed which, rather than defining it as a goal or achievement, departs from an integrative model of engagement with the aim to facilitate emergent insight, knowledge and interaction that could not have been foreseen or designed in anticipation of a specific outcome or solution to a problem.

In addition, transdisciplinarity is not exclusively an aspiration to move outside disciplinary frameworks, but can just as well be provoked by an involuntary confrontation with insights and concerns intruding into disciplinary practices which stimulates, or in some cases forces, the redefinition of their established scopes, problems and methods.

Roadblocks

Aside from imprecise uses of the term, which contributes to a general skepticism, there are real roadblocks to transdisciplinarity which need to be addressed. These are:

* Inflexibility of mobility beyond and between institutional frameworks. The increasing permeability between industry and universities has encouraged interdisciplinarity but has paradoxically led to an increasingly conservative culture of provision which more closely matches the existing (rather than future) employment market.

* National funding for university research recognizes the virtues of transdisciplinarity/interdisciplinarity and multi-disciplinarity but still depends upon evaluation processes that rely on established fiats of experts in disciplines not necessarily fluent in approaches beyond their area of specialism.

* Criteria for existing career and tenure tracks in research are informed by standards and expectations established by professional societies. Individual career tracks in transdisciplinarity are niche pathways in the social sciences and the arts and, at best, excursions from the mainstream in the sciences.

* There is a genuine and significant anxiety that transdisciplinarity (and even interdisciplinarity) will necessarily lead to a loss of focus and a consequent lack of rigour. This roadblock is compounded by the inevitable difficulties of communications between specialists.

* The ambitions of the market with its short- to medium-term risk are more comfortable with discrete disciplines with substantial long-term track-records of research return.

Opportunities

* There is an unprecedented structural change in the production, dissemination and storage of knowledge brought about by a more democratic access to databases. Universities and archives are no longer unchallenged gateways to acquired knowledge. This provides new opportunities/challenges for rethinking the role of the university.

* A significant change in first world demographics (longevity, distribution, mobility and kinship) provides new opportunities/challenges for knowledge exchange, storage and transfer as human capital.

* More permeable national boundaries, mass transport, electronic networks, linguistic dominance of English, provide new opportunities/challenges for exchange and comprehension.

* Interdisciplinarity and multi-disciplinarity have facilitated comparative methodologies which have provided a framework for the management of large, disparate data-sets. Transdisciplinarity offers a more systematized way of management, synthesis and evaluation of knowledge.

* The increasing focus on transparency and knowledge exchange as a consequence of research is being met by radical approaches to publishing platforms. This follows a trend in the Arts and Humanities which has had the effect of closing the gap between the university and the public.

Proposed actions for enhancing collaboration between sciences and engineering with practitioners in arts and design

* Universities should consider themselves more as a locus for criteria in relation to methodological practices than arbiters of values informed by tradition.

* If funding regimes wish to pay more than lip-service to transdisciplinarity they will need to consider radical changes to their review processes in order to include equal weighting for transdisciplinarity. For this they may need to consider the value of the network above its outcome.

* There should be investment in research network developments that regard transdisciplinarity as a topic and concern relevant to new research in traditional silos.

* There should be investment in soliciting meta-approaches to transdisciplinarity informed by grounded research in the Sciences, Humanities and Arts.

Position statement RE: Transdisciplinarity:

Since 2010 the International Network for Transdisciplinary Research (INTR) led by Transtechnology Research, Plymouth University, has brought together eminent researchers to consider more precise and useable understandings of transdisciplinarity in response to the urgency of high-grade collaborations led by immediate and burgeoning needs. It has proceeded from the inherent confusions and problems arising from a generalized and unreconstructed use of the term as a fashionable synonym for versions of multi-disciplinarity and interdisciplinarity. We take the view that the aim of transdisciplinarity is to facilitate emergent insight, knowledge and interaction that could not have been foreseen or designed in anticipation of a specific outcome or solution to a problem.

In this sense the model of transdisciplinarity proposed here takes a more modest approach, in which the emergence of a new or differently posed question, an unexpected facet of perspective or a entirely new question completely independent of the inquiry in process, are valued in their own right and not sidelined through the common problem-driven approaches that limit the inquiry through the pressures on short-term, or immediately economically or materially viable, outcomes. It calls for the development of theoretical, conceptual and practice-oriented approaches to transdisciplinarity as both, a post-hoc analytical process for the qualitative synthesis of collaborative research in interdisciplinary frameworks, and as methodological framework to forge innovative approaches to research collaboration that is inquiry-driven and seeks to identify new topics and concerns. In this way transdisciplinarity is sought to bridge disparate areas of discourse and research topics not merely by transcending or transgressing disciplinary boundaries around problem-driven inquiries, but by letting the inquiry in itself drive the methods, tools and theoretical formation in order to stimulate the identification of new

concerns, insights and topics that emerge from this cross-fertilisation of rigorous as much as imaginative scholarly research.

An emphasis in this approach to transdisciplinary lies on 'transformation' in the sense of the transformative potential of transdisciplinarity: in the recursive reflective impact on disciplinary practice, the dynamic interaction between researchers and objects of study that are conceived as integrative processes rather than disparate entities, in the consequential flatter model that breaks down certain hierarchical power-structures of the dominant institutionalised frameworks, as well as in the contingencies that dynamically shape the original research question from which the inquiry departed.

Martha Blassnigg, Michael Punt
August 09 2012

Gathering STEAM: Bridging the Arts and Sciences to Expand Public Interest in Science, Technology, Engineering, and Math

http://wp.me/P2oVig-fR

Coordinators: Marjory Blumenthal and Ken Goldberg

Many of the world's most important innovations resulted from collaborations among specialists with different backgrounds; almost all scientists and engineers recognize the power of collaboration and communication across STEM disciplines. As in STEM, creativity also flourishes in the arts and design. Brilliant and highly original novels, plays, films, and artworks engage and inspire audiences around the world, while people in all walks of life appreciate the fields of architecture, graphics, and industrial design. Those latter fields can translate directly into innovations. Even with steady progress in interdisciplinarity generally, connections between STEM and the arts and design remains limited, although they have been growing over the past decade. The trend points to a historic opportunity for experts from the Arts and the Sciences to begin a new series of conversations and collaborations.

Bridging the Two Cultures is a grand challenge. There is a fundamental asymmetry and complementarity between them: the word Science comes from the Greek "to cut." The word Art comes from the Latin "to join." The results can be extremely productive by expanding public interest and engagement with both sectors, bringing new topics to new audiences, and educating and inspiring the next generation to transcend existing boundaries to discover and create the future of innovations. STEM fields have always valued creative minds, and the best artists excel at highly unconventional, unorthodox thinking. Artists also are excellent at capturing and representing the zeitgeist in elegant, compelling ways. That quality suggests that fruitful collaboration between scientists and artists can yield not only interesting ideas and "products," they may also build in effective modes of communicating the value of that work to a wide audience.

We endorse the acronym STEAM as a shorthand to describe new collaborative initiatives that engage experts from both the Arts and STEM.[1] A key emphasis is new ways to achieve synthesis—connections among disparate modes of thought, viewpoints, and cultures—as a means toward the ends of discovery and innovation, as well as more effective education and communication about the intrinsic value of STEM and the Arts. We propose convening a cross-disciplinary committee to explore the potential for STEAM, focusing initially on computer science and engineering to formulate recommendations for action.

Background and Next Steps

In the early 2000s, the potential impact of linking computer science and the arts was recognized beyond the niches of computer graphics and computer music. The Rockefeller Foundation commissioned a study by the Computer Science and Telecommunications Board of the National Academies. Their report, Beyond Productivity (2003),[2] introduced the term "information

technology and creative practices" (ITCP) and spurred the Creative-IT program at NSF.3 In the ensuing years, the political and technological landscapes have changed dramatically. Understanding of both opportunities and issues may be served by conducting STEAM case studies. A few recent exemplary collaborations between scientists and artists include:

Doctor Atomic opera about the Manhattan Project
Breaking the Code, Broadway play about Alan Turing
A Beautiful Mind biography of John Nash
Laurie Anderson as NASA Artist in Residence
LOGICOMIX, graphical novel about the history of Logic
Bruce Nauman's installations using infrared surveillance cameras
The Listening Post and Moveable Type collaborative projects of Mark Hansen (statistician) and Ben Rubin (artist)

We believe now is the time to:

Define STEAM and characterize exemplary case studies
understand where are the most promising and high-impact activities, projects, programs, and domains and the roles of different kinds of players, such as universities, not- and for-profit private-sector organizations, government organizations, and philanthropy.

Explore what it would take to engage the most talented scientists and artists in STEAM consider novel mechanisms, such as engaging "principal artists" alongside "principal investigators" (as well as providing incentives to engage people who are hybrids, skilled in both the arts/design and computer science/engineering (or other STEM fields).

Engage leading artists (fine, applied, and performing) and designers with experts from STEM fields to collaborate on new ideas and approaches that can effectively reach the broader public and provide the foundation for future innovation, education, and synthesis.

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1 We recognize that some use STEAM to focus on educational activity; we use the term more broadly to cover research and other productive output as well as the education that enables it.

2 See http://www.nap.edu/catalog.php?record_id=10671 and http://sites.nationalacademies.org/CSTB/CompletedProjects/CSTB_042322.

3 See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501096, solicitation 09-572.

Creative Artificially-Intelligent Agents for the Arts: An Interdisciplinary Science-and-Arts Approach

http://wp.me/P2oVig-c4

Coordinator: Jonas Braasch

Advisors:
Selmer Bringsjord, USA
Ted Krueger, USA
Johannes Goebel, USA
Pauline Oliveros, USA

Artificial Intelligence (AI) has made impressive progress since its start in 1956. It now influences our daily lives, as AI systems are an integral part of consumer technology today, from SIRI to automobiles to Semantic Web. However, while AI systems can be very successful if they are precisely told what to do (e.g., perform a parallel parking task, play chess), they are usually useless if the objectives are not clearly spelled out. They can learn along a precisely given trajectory (e.g., to learn to understand spoken text or compose an instrumental music piece in the tradition of JS Bach), but they don't break rules to produce something more exciting. Deep Blue can play chess, but if you present it with a game implemented on a chess board, it will be lost. In short, machines are simply not very creative.

The idea of this White Paper is to form an intellectual think tank to overcome existing roadblocks and investigate alternative strategies in AI. Among the items that will be discussed is the implementation of design oriented processes for AI systems. Artists and designers often work on a less hypothesis- or goal-driven approach as compared to scientists and engineers; they pursue an open-ended, purely experimental approach instead, where the outcome of each phase informs the next one, not necessarily having a fixed goal in mind. Along with this approach, there is a need for better AI evaluation systems that can judge the outcome more freely than just examining the results along an externally given set of rules. Using the experience of artists with the abstract, can we make agents more creative by allowing them to be continuously evaluate what they accomplish? How can we create AI systems that can develop and evaluate their own concepts?

Part of this discussion will include the creation of a network for more complex AI systems that simulate several areas of the brain, or the abstract AI equivalent, simultaneously, by using a meta-concept to connect existing AI modules using a UDP protocol in a computer-cluster network. Another central aspect is systems that can draw on different algorithms to perform a task, making the selection part of the creative process. Along the same lines, we can look into web data-mining methods that allow these machines to receive information beyond what is given to them by the experimenter.

DXARTS : Lessons From a Decade of Hybrid Arts and Sciences Education

http://wp.me/P2oVig-c5

Coordinator: Shawn Brixey, Professor, University of Washington

In 2001 The University of Washington created arguably one of the first true, large-scale, well funded, fully autonomous, hybrid arts and sciences degree granting programs at a top ranked U.S. research-university. Designed around a revolutionary new model of creative practice, technical research, and discovery at the frontier of art, science and engineering, DXARTS supported the emergence of a new generation of pioneer practitioners by fostering the invention of new forms of expanded collaborative research that synthesize advances in the arts, humanities, computer and information sciences, physical and biological sciences, and engineering. While the primary public attention toward DXARTS initially was the creation of the new doctoral program, the largest single cultural impact to-date has been the pioneering undergraduate program. Focused on original research at the undergraduate level, the DXARTS undergraduate program synthesized study across 15 fields of arts and sciences with particular focus on new hybrid fields in visual and aural synthesis, algorithmic processes, sensing and control systems, and telematics. At its zenith the program served close to 1000 students a year, 50% (by-design) were non-majors. Between 2003 and 2009 the increase in demand for the DXARTS major grew to compete with the traditionally highest ranked campus majors of business, engineering and computer science. Yet with ever increasing demand for the major, multi-year waiting lists for its courses and stellar student performance and post-graduate placement, the university terminated the program after only 10 years (the last undergraduate majors will graduate in 2013). This whitepaper will present a brief overview of the undergraduate program, its curriculum and focus, as well as integrate SEAD-specific interview questions and online surveys of the students who graduated between 2004 and 2013 with a hybrid arts and sciences degree. The interviews will investigate the students original instincts and decisions to merge arts and sciences – as well as seek formalized university education in this emerging area, how the educational decisions evolved into a rigorous personal hybrid practice, what specific fields of expertise did they draw from and blend, what kind of collaborations did they create and were drawn into, major topological features of their post-graduate experience, what artistic and scientific disciplinary foci do they define as their specialty or career currently, what contributions and breakthroughs are they actively pursuing, and how has the hybridization of arts and sciences impacted their movement in and around creative and technical communities. Data and feedback from the largest (to-date) contiguous cohort of university-educated hybrid arts and sciences students is invaluable to the growing SEAD community. This case-study will provide critical insight and lessons that can be applied to help formulate effective recommendations supporting the growth and broader impact of SEAD. Further the network of observations can be applied to help extend the ecological boundaries and intellectual economies of current hybrid arts and sciences collaborative practice, as well illuminate just-over-the-horizon developments for educators, encourage existing and future practitioners, and influence policy makers.

Using 'Processing' as a Stimulus for Producing STEAM

http://wp.me/P2oVig-8L

Coordinator: Ron Brown, Computational Artist/Educator/Programmer
http://ron-brown.artistwebsites.com

August 8, 2012

The Challenge and the Opportunity

Sir Ken Robinson [1][2] has called for a paradigm shift in our educational system away from the use of standardized testing and behavior modification drugs on our youth to one of enquiry and creativity in the arts and sciences. I think a great opportunity exists today to achieve many of the goals he advocates utilizing tools from the open-source community, in particular, a computer programming language called 'Processing' [3]. I believe Processing can be used as a stimulus for merging the worlds of art, math, science and technology to meet the challenge of changing paradigms.

Processing

Processing is an open-source (FREE!) programming language developed at MIT by two graduate students (Ben Fry and Casey Reas) that is targeted for visual artists who would like to utilize digital media in their endeavors but who lack computer programming skills. It has become so popular that several circuit board manufactures have developed boards that can use Processing to obtain sensory data and/or to control motors (think 'robots') and other devices. In addition, Processing can be used to obtain data from the Kinect 3D camera (Xbox) for visual explorers to investigate the realm of 3D interactive media.

Course

During the spring of 2012 I had the opportunity to teach a 'Programming with Processing' course at a small independent Buddhist high school [4] in Ottsville, PA. The course met twice a week for twenty weeks where each session was one hour twenty minutes long. The students varied widely in academic skills and backgrounds and came from several different school districts but all stated they were glad they took the course. One student stated he had known nothing about programming prior to taking the course but is now considering computer programming as a career. The only pre-requisite for taking the course was the desire to learn a computer language – no other strings were attached. On June 22, I was one of several presenters at a STEM to STEAM conference held in Baltimore, MD, where I talked about the course and showed images created by the students [5].

Potential Participants

I think a course using Processing to create images would be greatly appreciated by 'gifted' students, by students who are comtemplating dropping out of school because they are bored, students who may have gotten in trouble with the law, other 'high-risk' students and students in the 'general' population. The growing "home school" movement should not be exempt from the opportunity of utilizing Processing in its curriculum either. Another targeted population that should not be excluded is that of teachers who would like to explore Processing themselves and learn how it can be used in their own classrooms to produce some STEAM. I feel strongly that the only pre-requisite for any student should be the desire to learn a computer language. Let the student have the opportunity to fail in a 'safe' environment and learn from his/her mistakes. Computer programming is an unforgiving endeavor and attention-to-detail is a must that is soon learned. But, it's FUN!

References
[1] Sir Ken Robinson's 12-minute summary: www.youtube.com/watch?v=zDZFcDGpL4U
[2] Sir Ken Robinson's 55-minute address: www.thersa.org/events/video/archive/sir-ken-robinson
[3] Processing website: processing.org
[4] Tinicum Art and Science High School: www.tinicumartandscience.org/
[5] Innovate Our World Conference: www.innovateourworld.org/conference.htm

Processing Books
Algorithms for Visual Design Using the Processing Language by Kostas Terzidis (Wiley Publishing, 2009)
Making Things See – 3D Vision with Kinect, Processing, Arduino, and Makerbot by Greg Borenstein (O'Reilly, 2012)
Processing – A Programming Handbook for Visual Designers and Artists by Casey Reas and Ben Fry (The MIT Press, 2007)
Processing – Creative Coding and Computational Art by Ira Greenberg (friendsofED, an Apress Co., 2007)
Processing for Visual Artists – How to Create Expressive Images and Interactive Art by Andrew Glassner (A.K. Peters, Ltd., 2010)

A New Ecology of Learning: Ecological Systems as Pedagogical Models

http://wp.me/P2oVig-86

Coordinator: Pavel Cenkl – Sterling College – August, 2012

A SEAD White Paper Proposal

This proposed White Paper introduces a new ecology of learning and innovative connections between ecological and a humanities curriculum. Drawing on points of intersection between experiential liberal arts education, digital humanities, biomimicry, and ecopsychology, this paper will engage instructors and administrators in course development strategies and in helping students plan their own learning by using a systems approach to curriculum design. The paper will propose to reground liberal arts curriculum design by considering (1) how ecological thinking can provide a model for a more intentional and dynamic liberal arts pedagogy; (2) how digital technologies can help us develop more ecologically-focused learning environments and curricula; and (3) how instructors can integrate ecological thinking into new and existing courses, units, and overall curriculum design.

Science-Art Interactions in Asia With Particular Reference to India

http://wp.me/P2oVig-7X

Coordinator: Dr. Krishna Kumari Challa

Abstract: While North America, Europe and Australia are basking in the glory of new wave science-art collaborations and reaping all the benefits that these interactions are bringing, there are some parts of the world that are relatively untouched by these happenings! Asia, to which the Indian subcontinent belongs, remains almost immune to the developments happening around the world in this subject. With the exception of China, we hardly find any science-art projects here. Moreover, the few science-art interactions that are occurring are concentrated in China, India, Singapore, Indonesia, UAE and Japan. Interestingly these areas with healthy scientific backgrounds are relatively high on the economic scales too in Asia. If we search for science-art interactions in this region, we mostly come up with science and technology assisted art rather than pure science art. This paper discusses the reasons for the dismal performance of science art and science based art in relation to the dynamics of the art world mechanisms in this region and suggests ways to remove the road blocks to make science based art flourish here.

Bridging the Divide: Collaboration, Communication and Education in art And Science

http://wp.me/P2oVig-8X

Coordinator: Nathan Cohen

As an artist who works collaboratively with scientists I am interested in the potential for developing meaningful discourse and research that engages at the interface between disciplines and provides fertile ground for creative enquiry and experimentation.

Interdisciplinary research and collaborations in the field of art and science embrace the potential to explore diverse approaches to understanding the nature of the world we live in and the development of ways to communicate this.

In this paper I will be considering the potential in collaborative investigation and the experience of establishing the MA Art and Science at University of the Arts London, including issues arising and approaches taken in the creation, development and delivery of the course, and implications for how this might inform future programme development internationally.

Proposals will be made for developing collaborative projects and networks for communication to facilitate the sharing and dissemination of research in public and educational domains, with recommendations for actions towards advancing understanding and engagement with the field of art and science in the context of opportunities and obstacles experienced to date.

Media Art History International

Coordinators: Sean Cubitt (UK), Oliver Grau (Austria), Ross Harley (Australia)

Advisors: Jon Ippolito (USA), Christiane Paul (USA)

All media, and all artworks, decay. Electronic media are especially vulnerable; as a result of both the decay of magnetic and optical storage and rapid changes in technology, major works made even 10 years ago can no longer be shown or are disappearing without a trace. Our immediate concern is with the **imminent loss of both artworks and the technological infrastructure** they depend on. Sustaining magnetic and optical media and the platforms they depend on is the acid test of preservation: advancing work on them will have spin-off benefits for all forms of digital archiving. An equally pressing issue is that much of the knowledge about their creation, dissemination and impact is in the possession of a generation of pioneers, still living, but in old age. To date, systematic global preservation and documentation campaigns do not exist. At a second level of urgency is the necessity to construct networks of scholars, researchers, curators, collectors and archivists to ensure that the resulting archives can be shared internationally. This infrastructure requires the **formation of an association**, the **development of technical strategies** for sharing information and knowledge, and **the creation of new interpretive systems**. Many important online documentation and research projects are also disappearing from the web. As they falter, we risk losing their valuable material forever. Contemporary scientific research relies on access to shared data. The same is true of the Arts and Humanities, which lack a concerted international policy for sustainability and support of the digital heritage, such as exists partly in the natural sciences. As recently expressed in an **international declaration** (www.mediaarthistory.org), signed by more than 350 scholars, curators and artists, there is urgent need to create a stable international platform of interoperable archives, of expertise and support for important regional histories, and to internationalise research, modes of interpretation and shared resources to document and preserve, to promote study and appreciation, to create a permanent resource for future scholars, artists, curators and creative engineers, and to make major interventions in the understanding of media as the basic functioning of society.

Media art history can provide powerful evidence and arguments to correct common presuppositions and influential recent theses, and to develop new models of interpretation. To do so we need to combine the dispersed practices of our network of collaborators into a unique new network of research and dissemination by combining complementary areas of **art history, image science, new media studies and semantic computing** required to bring this high-gain project to fruition.

Questions to address

- How much is the Media Art of the 20th and 21st century related to previous art forms and where are there qualitative and quantitative discontinuities?

- What significant role do technological innovations play in the creation of new image worlds and what function has the artistic drive in the formation of new technologies?
- What significant new theorisations of the formation of diverse social, economic, political and cultural forms does comparative study of the evolution of image media and its technologies enable?
- What are the effects of using the semantic tools and technological infrastructure the project seeks to provide on scholarly work on images?
- What kind of documentation on the technologies of media arts are needed for systematic and concerted preservation?

Challenges

• National funding agencies understandably fund national projects, but the history of media arts, involving as it does scientific, technical and cultural movements, has a strongly international formation. Collections and knowledge about them tend to be distinctly national or at best regional, with a bias towards Western Europe and North America to the exclusion of immensely important histories of media arts in Latin America, Asia, Australasia and to a smaller but significant extent in Africa.

• The challenges of interoperability and of handling large quantities of mixed data (including different visual media, different languages, schematics and 3D documentation of devices and installations) in integrated and evolvable open platforms are too great for one discipline. It is vital to learn from current projects across science, engineering and the humanities, and where relevant to integrate our models with those pioneered by scholars assembled around SEAD and similar projects

• Some selection from the vast quantity of media artworks is inevitable, given the experience of film and television archives and increasingly of libraries. At present, that selection is extremely ad hoc, based only on the interests and criteria of a single generation of scholars and curators, and lacking any institutional criteria. In many instances, national art collections do not include media art works, or have only recently begun to acquire them, leaving the task of archiving and critical assessment to initiatives reliant on ephemeral funding and projects with very specific goals and orientations. Two approaches are possible: developing shared criteria; or refusing to accept the canon-formation implicit in it. However, since not all works can be stored (or indeed restored), open debate on these issues is vital, but as yet has no platform.

Goals and Objectives of Research

Two visual art forms have been **pioneered in living memory: video and digital art**. They share with older mechanical arts, notably prints, photography and cinematography, qualities of archival vulnerability, low status, and now the risk that the pioneers of these forms may die before their works can be saved and the story of their struggles and achievements recorded. As **media evolution accelerates, the electronic arts are especially vulnerable to decay**, both of individual works and of the devices they were designed to play on. Therefore **encouraging the development and maintenance of collections is our first goal**. The profusion of invention associated with media arts has immense potential for future innovation. The systematic overview

which diachronic database configuration allows is vital to preserving this inherited ecology of innovations.

To achieve these goals, we need new tools for online access, **search and comment capable of integrating different kinds of archive**. These tools need to combine digitization of pre-digital media and technical artifacts and integration of archives reflecting the range of holdings germane to media art historical enquiry. We refer to this program of work as the **Interactive Archive of Image Media (IAIM)**. Both in order to establish this, and to reap the benefits of it, we need **a long-term sustainable network** of interpretation and discussion which will promote interest in and therefore support for the media art heritage.

While art history has a standard lexicon of historical movements and trends, these have not often been articulated with the technical forms of media, while media historians and historians of technology have rarely ventured into the field of aesthetics.

The goals and objectives we want to achieve with MAHI:

- encouraging the development and maintenance of collections
- developing new tools for online access, search and comment capable of integrating different kinds of archive
- building a long-term sustainable network of interpretation and discussion
- constructing new models for media art historical research
- sharing expertise with colleagues across disciplines in developing, maintaining and evolving systems for handling diverse mass databases
- building bridges to existing art institutions, technology collections and the public

Using Smart Games and Immersive 3d Cloning Technology as a Tool for Highly Personalized & Social Contextual Interactive Learning and Teaching in all Levels of Formal, Online, Industrial and Personal Education

http://wp.me/P2oVig-dS

Coordinator: Carol Davis

This paper is designed to engage anyone administering a learning environment in course development strategies that assist in learning and teaching by using a games based approach to curriculum design and instruction. Because games are so ubiquitous in society, every person can potentially learn in this way.

The goal is to collaborate with games technologists, computer programmers and arts and science educators to create a mass multi-player* smart game/learning tool based on 3D cloning technology that provides a highly personal learning experience for the user. This experience can be used to create a learning environment/subculture where the user/clone becomes vested in the processed by being immersed in a virtual interactive environment that is social media based and that the user/clone can control. Learning is done in the context of the subculture. As an example: a health based game environment teaching nutrition and weight loss where as the user/clone (playing himself) plays along he sees his (or her) progress in real-time via their clone. By playing the 'game', the user is enticed into learning more about something they have already demonstrated an interest in.

We have a large pre-existing population of game players that is only going to get bigger. Add to that the fact that most people are now so used to being entertained and constantly entertaining themselves that their attention span is directly proportional to the degree to which they are entertained. Learning has changed. Much of it is not what we teach the student but what the student is able to teach themselves with education assists. The technology of games can cross all disciplines and subjects and is an excellent vehicle on which to place a curriculum that introduces and teaches learning objectives, and rewards outcomes.

The primary stakeholders are the students and the purveyors of education from all industries.

*individual play is also possible

Davis & Strathmann: A Case Study in IP Arising in Art/Science Performance Research and Transdisciplinary Collaboration

http://wp.me/P2oVig-mV

Coordinator: Josie E. Davis

In this paper, I will discuss the projects and practice of the art/science research collective Davis & Strathmann. I will use Davis & Strathmann as a sample case study in transdisciplinary, collaborative, practice-based performance and design research with a unique history of unresolved trademark and intellectual property conflicts between members. I will consider the history of two projects, Sink and Hunter/Symbiosis, as an example of work first conceived by the author and developed by Davis & Strathmann as part of a mobile exchange between the U.S. and Argentina and, later, as part of a six-week art/science residency at the Helen Riaboff Whiteley Center at Friday Harbor Laboratories. These projects foreground the collective expertise of Davis & Strathmann in audio and media production, performance and critical studies, visual design and specifically, the application of these shared involvements toward art/science research.

Issues arising from collective and shared practices including divergent views on the role of performance as documentation, artistic ownership, process versus product, ethics and professional discourse, and transparency are examined in the context of these works. In particular, this study will examine a series of unresolved IP challenges facing the author over a period of two months following the end of the residency at Friday Harbor Labs and the dissemination of the collective including image rights and the abuse of online web permissions. Furthermore, this study will examine the actions taken by both members that contributed to these issues, how certain actions may have been avoided, and steps currently taken by the author to prevent the recurrence of IP conflict and to protect future stages of these and additional works. In closing, the study will make Suggested Actions for how these lessons can be observed and utilized by individuals and transdisciplinary collaborations hoping to avoid and move through IP conflict in the field.

Paradigm Shift

http://wp.me/P2oVig-aQ

Coordinator: Jean Delsaux

For french philosopher Gilbert Simondon ("Du mode d'existence des objets techniques", "About the mode of existence of technical objects"), the magical way of thinking of prehistorical cultures splitted into two systems of thought : religion and technique. Philosophy was later on withdrawn from religion and Science from technique. He adds that Aesthetic appeared at the very place of this separation.

We can actually consider that Science is sometimes a generalization of technical experiments, would it be afterward the condition of technical developments. So the relationship between technique, engineering and science is yet not that obvious, not that totally coherent. Since technique becomes technology, it is structured as a language, informatics itself is a language, so is it still a technique or yet a science?

Techno-sciences, cybernetics already have an history, one speaks about second cybernetics, situated robotics with Rodney Brooks who, rejecting the idea of a central computing unit, showed that intelligent behaviors could emerge from cooperation between simple and independent systems.

Art itself has a complex relationship with science and technique, which is not due to the same reasons in both cases. Art is as well experimental and speculative, within its own practice and theory.

So I would like to discuss the relationship of art, its links, rather with experimentation, technique and science, philosophy, than stand to the usual dichotomy Art/ Science, technique being a mere tool, related to Science and Design being an application of art.

Perception, technologies, interaction

Technologies themselves refer more and more to humanities and we come across this assertion concerning cognitive sciences within their relations to technology, to the augmented organism : cognitive sciences teach us that it's with our moving body that we create and integrate the space around us, that we determine, spot and perceive it. Technologies modify this coupling between our body and its environment.

Cognitive science study perception thanks to neuro-imagery, artists are perception practitioners. Artists also organize images as results of these experiments in perception, which is not to be confused with simple sensations, passive reception of stimuli.

They elaborate these images not in order to duplicate the world nor visualize their dreams, but to try and understand the world around them, the relation they have with it, to find one's bearings, and establish a possible connections with other people.

As Panofsky showed it, Perspective, which was a high level technical procedure, related to geometry and optics, was a symbolic form as well, insofar as it was leaned upo a philosophy of space, itself associated to a philosophy of the relationships between the subject and the world.

Piotr Kowalski could say, already in the eighties, he was a painter of nature as far as he used contemporary technologies, these ones being « our ears and eyes to perceive the world ».

He produced a number of creations functioning in empathy with the world, works of art very soon defined (already in the 60) as interactive. He also underlined their irreplaceable physical presence, as far as this presence, intervening
between his body and the world, provoked, through its irruption, a reaction, an interrogation, an emotion.

We are in a period of History where subsist places (museums, galleries, cultural centers) which where conceived, organized in order to present works not related to any specific context.

The interactive work implies the participation of the spectators body, it makes it necessary to operate a most often driving coupling, would it be volunteer or not, between itself and the spectator.

The consequence of this is that the reception conditions of the works of art are modified even more than their production procedures. The relation to the work of art evolves, but it's even more difficult to let the places where they are shown evolve as well. It's interesting to quote that some of the most appropriate structures for these works seem to be industrial wastelands, as if they would spot the end of a world, the need of new social, economical relationships, as if the works would fed on the disappearing of one of Foucault's confinement's places: the workshop, the factory, the plant.

The city, considered as a virtual environment

My work as an artist led me to cooperate with several scientific and technical structures, so as to create several structures devoted to collaborative projects between artists, scientists, engineers and theoreticians.

My direction of research concerns space, its figuration, or rather the visualizations, the modelings that result from the experimentations made possible due to the substitution, "augmentation" technologies.
Mathematics and Physics since Einstein and Planck, Poincaré and Riemann (for example) and so forth, have proposed other structurings, other representations of space, other geometries, but it is still difficult to embody them into our everyday life. Actually, if Alain Berthoz can say that with our otolithic sensors, it's the cartesian space that is integrated into our physiology, the same does not go for these latest mathematical or physical concepts.

The hypothesis I should develop in this paper would be that within our everyday practices we shift, without realizing it very well, outside of the perspective space we inherited from

Renaissance. Our representation overlap each other, multiply, achieve a constant sale, location variability. Perception and operative representation of distances evolve along with the concerned uses and means of transport.

Perception and therefore consciousness are more and more automatized, shared, networked, and it is henceforward not only an instrumented subject who thinks, memorizes and feels, but a multiple body, augmented, interconnected, surveyed, perceived as much as perceiving, acted as much as acting, that shows up.

I'm now working on a research program involving developers, neuro-cogniticians, VR platforms, behavior analysis technologies that refers to my conception of the urban landscape and environment as immersive environment.

In this paper I would like to illustrate, through my experiments the fact that

- it is becoming more and more difficult to separate scientific, technologic and artistic procedures, at least within artistic creation. On the other hand, show how art can participate to scientific and technological developments.

- the nature and status of author, artwork, "audience" are evolving due to the evolving production, creation, displaying, broadcasting modes.

I shall lean my demonstration on the experiments I made as an artist
http://www.jean-delsaux.com

But also as a director of Brouillard-Précis experimental Workshop (devoted to video and 3D animated pictures technologies). And as director and cofounder of LEEE, Laboratory for Aesthetics, and Space Experimentation, University of Clermont-Ferrand,whih is devoted to research based on artistic experimentations concerned by science and technologies.
http://www.labo-leee.org

Interdisciplinary Courses, Positions, PhD, in Italy

http://wp.me/P2oVig-ax

Coordinator: Michele Emmer, Dipartimento di Matematica, Università di Roma "La Sapienza"

The paper elaborates on my experience with interdisciplinary courses between mathematics and a number of subject (art, architecture, …) throught many years and some difficulties that arise thereupon.

First of all I would like to say that these academic activities started as a personal experience more than 30 years ago. For many years I was (and I still am) officially a full professor in Math and non officially I worked on the relationships between mathematics, art, architecture, biology, physics, literature, cinema. At a certain point of my activity my work on art and math was recognized as an official work in mathematics.

I was very proud when I received as national coordinator two grants in 2007 and 2009 (the rules exclude applying for a grant every year) on mathematics and modern art. These grants were assigned by the Italian Committee for National Funds (PRIN) for mathematics. So the math researchers decided to support my research on art and math.

Due to the economic crisis in Italy and in the funds for the Universities a choice like this means that other research, strictly math research, did not receive a grant. These was unthinkable 30 years ago, even 20 years ago.
Due to the change in the attitude of the Math community it was possible to undertake several projects:

- The "Mathematics and Culture" international yearly conference in Venice starting in 1998. Part of the conference is dedicated to art and math. Proceedings in Italian and in English by Springer verlag, more than 25 volumes. From 2012 a new series "Imagine Math: math and culture" always published by Springer verlag. The next conference will be particularly interesting because speakers will include Linda D. Henderson on a project for an important exhibition on art and math in Italy.

- 20 films of the series "Art and Mathematics" produced in several languages, shown in the Italian State Television and other TV channels, including the film on Soap Bubbles, featuring the well known mathematicians at Princeton University Fred Almgren and Jean Taylor. A film on Escher with Roger Penrose and Donald Coxeter, distrubuted in USA for 20 years, a film based on the book Flatland all in animation, original music by Ennio Morricone. All films were produced in french for the Citè des Sciences de la Villette in Paris. Most of the films produced also in English and Spanish versions.

- In 2004 I launched a completely new course, existing only at the University of Rome, called "Space and Form", an interdisciplinary insight of the relationships betwwen mathematics, art, architecture, biology, literature, theatre, cinema with a myriad of applications in all these fields during the XIX and XX century. It involves students of the

last years in math, design and architecture, including a small group of ERASMUS students from several European Countries.   The number of students are usually every year between 50 and 60, adding to more than 450 in seven years. There is a project to write in English a text book of the course to be used of course not only in Italy, but I hope in Europe and elsewhere.

Soap bubbles are part of the topics of the course on "Space and form". There is the project to publish an English version of the book.

Architects, Like Massimiliano Fuksas, artists, writers, filmmakers like Gustavo Mosquera, came to present their works to the students for the course "Space and Form"

One important result of this activity was:

- The Literary Viareggio Award 2010 (Best Italian essay 2010) for the book on "Soap Bubbles" I wrote in Italian. The same year the International Viareggio Award was given to Vargas Llosa. A short abstract of the motivation of the Jury, most of them university professors):

"Emmer wrote an extraordinary book in which mathematics and science, analytical rigor and artistic sensibility is a perfect match, …a real adventure of intelligence, which he reconstructs in masterly fashion by giving us a book not only interesting, but rare."
The same book also received the Premio Capalbio Scienza 2010 (Best science book ")

The real problem

- There is an interesting discussion developing in Italy and Europe on the possibility to introduce interdisciplinary curriculum, master, PhD in art and science. The real problem is to obtain positions for researchers in this area. In Italy in particular there is a major problem: in which discipline can we insert an interdisciplinary course? Can you ask a math department for a position for a young researcher on art, math and architecture? In Italy it is impossible for the time being. As it is impossible to obtain any dedicated PhD program or any contract for lectures. I cannot recommend my students to continue to study art, math, architecture, as there will be no future for them.

- At a European level however, there is a new PhD in France and Swizterland on art and science for artists and designers, as well as interdisciplinary seminars on art and science proposed for 2013 in Paris. While at the European level it is possible to ask a grant to organize an exhibition on art and math this is out of the question in Italy.

- In 2008 we started an important project of a large exhibition on math and modern and contemporary art to make visible all the work that has been done in the last years. This year there was the exhibition on art and math at the Cartier Foundation in Paris (nor really satisfactory) and the small exhibition on Henry Moore and math at the Royal Society in London.

Final Comments

Due to my personal experience and my knowledge it will be easier to organize interdisciplinary courses, masters, perhaps PhD, at the European level. It will be probably easy if the different European countries put their experience together to ask for an international and interdisciplinary important Grant for the next years. It will be probably more complicated to cooperate also with USA. But Leonardo is a good way to cooperate.

Between Barriers and Prospects: Merging Art Performance and Engineering in Mobile Music Education and Research

http://wp.me/P2oVig-ft

Coordinator: Georg Essl, University of Michigan

There is little doubt that mobile smart devices are a socio-cultural game changer. The reach of sophisticated, networked, interactive computational technology will soon be universal. This means that technology with tremendous capabilities for artistic expression open up a space of exploration for new forms of culture and creativity.

However, this potential is as yet to be realized. Currently we face a barrier of access for most users of mobile technology due to the complexity and sophistication of the devices and the depth of domain knowledge required to build creative applications on them. Typical users of smart devices are not trained engineers, nor necessarily trained performance artists. Hence we see the continued effort of lowering the barrier of entry as a critical aspect of the advent of mobile smart device adoptions for creative expression.

Mobile smart devices are also shifting various technological paradigms. Creative content creation on laptop and desktop computers assumed a given interaction model centered around keyboard, large monitor, and mouse. A multi-touch centric device with a small display and additional rich input sensors such as cameras and motion sensors replaces this. Hence existing models for supporting computational creativity have to be rethought and fitting models of Human Computer Interaction need to be developed.

To this end we develop an environment called urMus, which seeks to provide a mobile-centric design of open, and accessible creativity support. In the paper we will discuss the state of the project, some past experience in using it in workshops and performance. Finally we discuss a range of open challenges in research, dissemination, and adoption. For example, industry is cautious of giving open access to their devices for reasons of allowing monetization and to combat security concerns. This interferes with open creative expression and its dissemination. Building awareness and advocacy are important to mitigate some of the impact of these problems.

Further there is a need to rethink curricula. We designed a senior level undergraduate course titled "Mobile Phones as Musical Instruments." It is cross-listed between the College of Engineering and the School of Music, Theater and Dance at the University of Michigan. The placement of such interdisciplinary course has numerous challenges but also clear benefits. The course is designed to blend students from diverse preparatory backgrounds. All students engage in the full range of activities in the course without distinguishing if they pursue education in engineering or the arts. We discuss describe advantages and pitfalls of this course design. UrMus is the central programming platform in our course. Its design allows rapid access, early rewards, and a sense of mastery. As students become more proficient the design allows deep engagement and open expression. An exit surveys show that students largely see the approach as successful, independent of prior background.

Mobile smart devices have already had a drastic impact on how we use computation and expanded who is able to participate. The prospect of enabling broad participation on technological creativity is tremendous with potential impact on who can enter STEM and creative fields.

Bridging the Silos: Curriculum Development in the Arts, Sciences and Humanities

http://wp.me/P2oVig-3R

Coordinator: Kathryn Evans, University of Texas at Dallas

Advisors:
Nina Czegledy, Canada, Hungary
Christo Doherty, South Africa
Roger Malina, USA
Eddie Shanken, USA
Paul Thomas, Australia

May 7, 2012

Higher education has long been departmental in nature (dating back to the 19th century), and becomes more restrictive as a student moves from "interesting" Freshman seminars bridging a wide range of topics, through their major courses in a departmental area and finally into graduate school, where a single department awards their degree based on a usually narrow set of course requirements and a thesis or dissertation. However, in the 21st century, investigators are finding that there are often tools, information, resources and even points of view from other disciplines that can elucidate and even answer the problem they are studying. Many studies recommend "big" solutions that require fundamental changes to hiring, promotion and tenure, funding and support, and evaluation of grant proposals and publications in cross-disciplinary areas. This study recommends a "small" solution: the creation of a compendium of cross-disciplinary curriculum that will encourage faculty to offer such courses. A web site was created and submissions were posted at http://www.utdallas.edu/atec/cdash/, based on a Call for Courses in 2009 via the Leonardo Journal (http://www.leonardo.info/). Recommendations for further work are an expansion of the current site to include more courses and broaden the geographical scope via a call for papers in both domestic and international organizations; an "Art-Sci Cloud Curriculum" that would be a shared network resource; and sponsorship of an international conference on Cross-Disciplinary Curriculum.

A Digital Arts Community Within HC

This paper will report on the first year of the Digital Arts community at CHI 2012, the ACM SIGCHI Conference on Human Factors in Computing Systems. CHI is a large and prominent international conference on human-computer interaction (HCI). CHI formally recognizes and supports communities that it vets within the larger organization of the conference. For example, other communities include the Design, Healthcare, and Child-Computer Interaction communities. Specifically, we will report on the process of creating the community, the goals of the community, the practical infrastructure that the community provides to arts-related research, and results from the first year.

After a series of related and well-attended meetings and workshops in recent years at CHI, the Digital Arts community was founded by computer science Professor David England of Liverpool John Moores University and artist Jill Fantauzzacoffin of Georgia Institute of Technology. A steering committee consists of Linda Candy, Ernest Edmonds, Celine Latulipe, and Thecla Schiphorst. At CHI 2012, we established a program of events to address issues in interdisciplinary research, collaboration, evaluation, and innovation discourse. Eighteen archival arts-related papers were presented at CHI that year.

Themes which emerged during the 2012 conference include the role of the Digital Arts community at CHI, relationships between this community and other technological arts communities, the relationship between the arts and innovation, STEM to STEAM, arts research, and the importance of including diverse voices and visions. We also discussed the value of articulating lines of arts research, methodologies and epistemologies of practice-based research, and emergent interfaces in experimental media as HCI interfaces to be studied in their own right.

The proposal for the Digital Arts community:

England, D., Fantauzzacoffin, J., Latulipe, C., Edmonds, E., Sheridan, J.G., Pobiner, S., Bryan-Kinns, N., Reeves, S., Tanaka, A. Digital Arts and Interaction Community: Building Bridges. Available at: chiarts.gatech.edu/proposal.pdf.

Conference fora publications related to the Digital Arts community and the events at CHI 2012:

Fantauzzacoffin, J., Berzowska, J., Edmonds, E., Goldberg, K., Harrell, D.F., Smith, B.K. The Arts, HCI, and Innovation Policy Discourse. An invited panel at CHI 2012.

England, D., Fantauzzacoffin, J., Latulipe, C., Schiphorst, T. Digital Arts and HCI in Collaboration. A course offered to attendees of CHI 2012.

Fantauzzacoffin, J., Candy, L., Chenzira, A., Edmonds, E., England, D., Schiphorst, T., Tanaka, A. Articulating Lines of Research in Digital Arts, HCI, and Interaction. A Special Interest Group session (SIG) at CHI 2012.

England, D., Fantauzzacoffin, J., Bryan-Kinns, N., Latulipe, C., Candy, L., Sheridan, J.G. Digital Art: Evaluation, Appreciation, Critique. A Special Interest Group session (SIG) at CHI 2012.
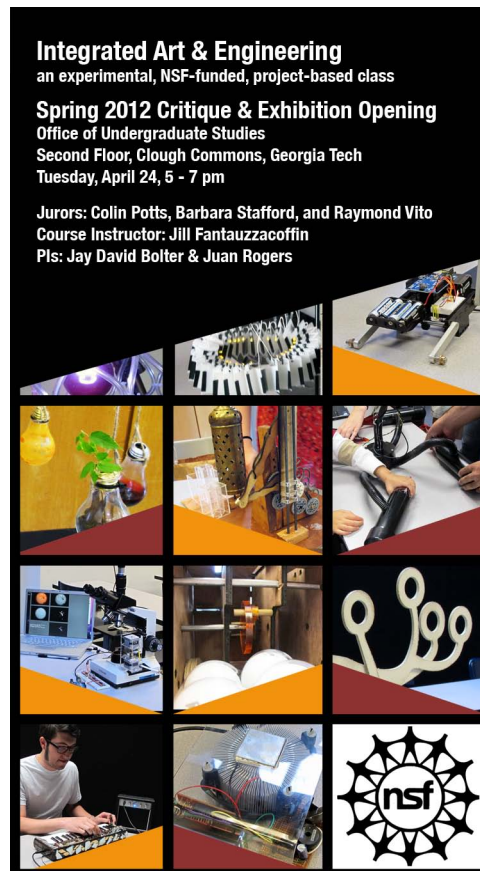
All publications are available in *Extended Abstracts of ACM Conference on Human Factors in Computing Systems (CHI 2012)*. ACM Press, 2012.

An Integrated Art and Engineering Undergraduate Course

http://wp.me/P2oVig-dW

Coordinator: Jill Fantauzzacoffin, Georgia Institute of Technology
White paper abstract submitted to NSEAD, 15 August 2012

This paper will report on an experimental, project-based course at Georgia Institute of Technology which integrated practices from the visual arts and engineering. The course was titled *Projects and Practices in Integrated Art and Engineering* and was offered as a six-credit studio course during the Spring of 2012. The design of the course was informed by a qualitative case-study of the work practices of artists and engineers as they developed technology. Both the study and the course were funded by the NSF CreativeIT program under the project name *Qualitative Analysis of Creative Practices in Parallel IT and Art Projects*, with Jay Bolter (Professor, Georgia Tech Digital Media Program and College of Computing) as PI and Juan Rogers (Assistant Professor, Georgia Tech School of Public Policy) as Co-PI. Jill Fantauzzacoffin (Ph.D. Candidate, Georgia Tech Digital Media Program) is the author of the project and the lead researcher.

For our research, we identified artists and engineers working separately to develop similar technologies and studied their work practices in parallel. We found that studying the practices of artists and engineers conceptually bound together through similar projects and technologies throws the creative strategies and design decisions of each group into relief. Two primary patterns of creative building process emerged to form endpoints of a spectrum of practice. These processes correspond with stances toward the end state of the project, as well as the negotiation of the uncertainty inherent in the creative process. Briefly, we use the term *teleological* to characterize a process that specifies a clear end goal and a well-formed, detailed design at the beginning, and then projects this design to the end state, from where it channels the development of the technology. We use the term *stochastic* to describe processes that are less determinate. Stochastic processes proceed through multiple series of decision points, each of which may branch into multiple potentials. The indeterminate nature of the process allows openings for metaphor and experience to inform an emergent design.

The undergraduate course, *Projects and Practices in Integrated Art and Engineering*, was motivated by technological traditions in the fine arts, the changing nature of building and innovation, and a sense that by combining practices from the arts and engineering, we could broaden the pool of resources students can draw upon. The goals of the course were to:

- broaden students' creative abilities by enabling them to consciously leverage skills, processes, and insights from both the arts and engineering in the pursuit of their creative work
- cultivate students' awareness of creative process and the relationship between process and outcomes
- support students' creative skills in the service of ideation, design, fabrication, presentation, and project analysis
- teach students hands-on fabrication and prototyping skills, and
- introduce students to working interdisciplinarily

Multiple engineering, computer science, computational media and arts disciplines were represented in the student makeup of the course. Our assessment results show that introducing engineering students to foundational art practices and processes enables them to draw upon broadened creative resources. These results form a counterpoint to problem-oriented, project-based course approaches. The approach of this course can be considered more foundational in that it directly addresses the students' subjective desire to create. Currently, the course is a contributing model for a new freshman engineering course at Georgia Tech initiated through the provost's office.

This work has been published in the following three papers:

Fantauzzacoffin, J., Rogers, J.D., Bolter, J.D. From STEAM Research to Education: An Integrated Art and Engineering Course at Georgia Tech. In *Proceedings of the IEEE Integrated STEM Education Conference (ISEC 2012)*. IEEE Press, 2012.

Fantauzzacoffin, J., Rogers, J.D., Bolter, J.D. Articulating Creative Practice: Teleological and Stochastic Strategies in a Case Study of an Artist and an Engineering Team Developing Similar Technologies. In *Proceedings of the Sixth International Conference on Tangible, Embedded,*

and Embodied Interaction (TEI 2012). ACM Press, 2012.

Fantauzzacoffin, J., Rogers, J.D., Bolter, J.D. Negotiating Uncertainty: Process, Artifact, and Discourse in a Case Study of Technologies to Address SIDS. In *Proceedings of the Second International Conference on Creativity and Innovation in Design (DESIRE 2011)*. ACM Press, 2011.

From Installation to Innovation

http://wp.me/P2oVig-dZ

Coordinator: Jill Fantauzzacoffin, Georgia Institute of Technology

This paper presents a case of novel technologies emerging from art practice. Over the past few years I have been developing an art installation from a large, live Jade plant. Some of the round, spongy leaves are pruned, and then magnetically reattached so that they can be plucked from the branches and replaced. These leaves have electronics incorporated into them so that a visitor can hold the leaf to their chest and collect their heartbeat into it. The leaf then pulses with the visitor's heartbeat and can be placed back onto the branch. After a time, the plant's different leaves will be pulsing with the various heartbeats of visitors. The leaves can be touched and these sensations can be felt by visitors as well.

This piece necessitated a novel, flexible, haptics (touch sensation) technology. The technology developed for the piece and the design of the interaction led to the development of an infant soothing blanket. A parent or caregiver of an infant can hold the blanket to her or his chest to collect their heartbeat into the blanket, and then wrap the infant in the soothing pulses of their heartbeat. Rhythmic sensations can soothe infants. Additionally, medical research suggests that low level rhythmic sensations can also guard against Sudden Infant Death Syndrome (SIDS). The blanket is being further developed to address this possibility.

Textile-based haptics can also used in post-traumatic stress disorder (PTSD) therapies. This haptics technology can additionally be used in other touch interfaces such as cell phones, industrial controls, and videogame controllers to give finer, higher resolution haptics. In November 2011, Georgia Tech's Office of Technology Licensing filed an international PCT patent application for these haptics technologies and applications. More recently, the project was granted research and development funding from the Georgia Research Alliance. The goal of this funding is to move university research into technology startups.

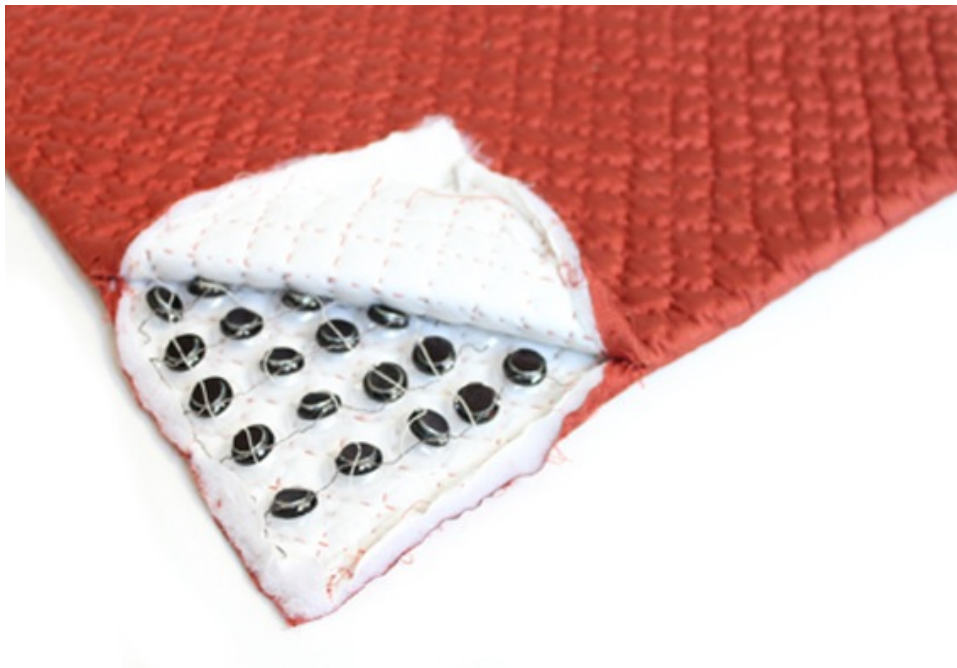**Figure 1.** *Jade* **concept image**

Figure 2. Plant haptics

Figure 3. Preliminary blanket prototype

SEAD: To Success and Succession. Drawing on Pioneering Works and Forming a New Infrastructure

Coordinator: Bronac Ferran

Amnesia can dominate when it comes to building new forms of support for art/science/technology research and practice. Despite practical experiments and theoretical analysis stretching back for more than a century, there is often a 'year zero' assumption – a sense of building something entirely new. Structures and systems of support tend to come and go with few if any signs of critical accumulation. This White Paper will reference the lineage behind highly contemporary practices and argue that accessing the critical wisdom of earlier pioneers across arts and science borders is an important part of strengthening the seemingly new. Often these pioneers have had migratory careers, moving between institutions or even countries, which has contributed to a sense of dispersal of knowledge and a lack of integration into formal structures. We should explore some of the challenges involved with drawing together distributed viewpoints, disparate processes and (often) contrasting ideologies. We need to observe a continuum of 'praxis' alongside the joy in 'discontinuity' perfectly described by Jonathan Benthall when he commented, writing in Studio International in 1969, on how: ' discontinuities between science and modern art'…are….'as interesting as their interactions'. Benthall also wisely pinpointed the value of difference and divergence within SEAD practices. In his view: 'there is no apparent correlation between the stature of a given artist and the validity of his scientific assumptions'. In 1969, also in Studio International, the great artist-engineer Naum Gabo wrote about how he had seen little success in terms of bringing together the arts and sciences. This leads to a second very important challenge and question for this White Paper which is to ask how might we choose to evaluate success across the breadth of the terrain signified by a framework such as SEAD? Without evaluative processes there can be no methodology for learning and passing on wisdom. As curricula and reading lists are being formed to underpin emerging Masters courses in 'art and science' might the SEAD initiative finally help signpost a stable direction in this productively unstable terrain? Is it feasible to produce a summative assessment of what constitutes success in the interdisciplinary domain and what might this mean for future institutions? How might art and science pioneers now define success? How might the value of preceding events and practitioners be more readily accessed? The SEAD community is invited to contribute to the development of proposals to address some of these fascinating challenges.

The Landscape of STEAD In Brazil And the United Kingdom: A Comparative Study

http://wp.me/P2oVig-fa

Coordinators: Bronac Ferran/Felipe Fonseca
with Professor Karla Brunet

Within this White Paper, we will survey SEAD-related activities and identify significant developments in two contrasting countries - Brazil and the UK. We adapt SEAD to STEAD to include 't' for technology which Is very much at the core of this collaborative study. The word STEAD is also an old English word meaning place.

The work builds on a close history of exchange between digital media networks and arts-environmental communities in both countries as well as on earlier reports and publications including 'Mapping Digital Culture in Brazil' a report co authored by Ferran and Fonseca in 2008 and 'Paralelo: Art, Technology and Environment', a networking event and publication with Brazilian, Dutch and UK contributors held in 2009.

Our aim is to achieve a panoramic overview of the landscape of STEAD developments in both countries within policy and funding contexts, including research initiatives, pinpointing significant developments, challenges and opportunities. We will map, compare and contrast key trends and trajectories.

We believe the work may potentially form the basis for future comparative studies with a broader range of countries. Its methodology will be piloted and open for future adaptation as well as potential extension beyond the scope of this initial study.

A key focus in this initial stage will be on level and direction of funding of projects, shaping of funding policies, resources and structures of support. We will conduct intensive interviews with a selected group of people coordinating STEAD programmes and projects in both countries and create also a series of questionnaires, following the methodologies deployed within the earlier mapping report. Our work will also include desk and literature review. The analysis will cover a range of private and independent funding sources along with public and state support frameworks. We will seek to identify leading organisations and agencies working across and between the different STEAD sectors and track trends which we perceive as pivotal in this area. Our paper will also seek to address some of the complexities at work in the formation of inter-, multi- and anti-disciplinary support structures and explore the interplay between formal institutionalised bases and often more informal, networked or practice-led activities.

About the writers: Bronac Ferran is a writer, visiting lecturer at the Royal College of Art, London and former Director of Interdisciplinary Arts at Arts Council England; Felipe Fonseca is a writer, founderof Metareciclagem, Ubalab and Bricolabs networks and a Graduate Student at Labjor, Unicamp, Campinas, Brazil and Karla Brunet is an artist and Professor at the Federal University of Bahia.

Learning Computing through Game Experiences

http://wp.me/P2oVig-5p

Coordinator: P. Fishwick (http://www.cise.ufl.edu/~fishwick)

Computing Culture

The field of computing is found in a wide array of disciplines including information science, computer science, and computer engineering. The culture of computing, including its formal languages, practices, and practitioners, has permeated the broader cultures of society at large. We use digital devices including smartphones and video recorders on a routine basis, and this use has changed how we think. Programming a digital video recorder (DVR) requires knowledge of tree structures, state machines, and other fundamental formal constructs found within computer science. This knowledge is learned through informal experience rather than through formal means (e.g., taking a university course). Therefore, there is a general need to teach non-computer specialists about core computing concepts because of their cultural significance. People should learn about computing, as they learn mathematics, because of its ubiquity in modern life.

Roadblocks and Opportunities

One challenge in learning computing relates to the need to entice the learner into computing through something that they find interesting and relevant. Certain games serve as a general opportunity to address this challenge since there is a pre-existing culture of game players, and one need only use this as curricular vehicle for introducing learning objectives. Games are developed using multiple disciplines, and players of the games cross disciplinary boundaries; World of Warcraft is probably played just as frequently by artists as programmers. However, there is a more significant set of roadblocks in bridging the areas of SEAD (Malina and Strohecker 2012). One of them is so basic as to be easily overlooked: writing vs. building. Some of our core approaches in the SEAD disciplines are oriented toward writing. Computer scientists write code or programs, as do humanist scholars who write the "scholarly edition." The assumption of the former group is that algorithms, and most resulting code, are written. For the latter group, writing is the fundamental rhetorical device supporting criticism. Can we challenge these assumptions? Can an algorithm be defined by an analog machine (Fishwick 2012), and can the humanist's rhetorical mandate employ audiovisual artifacts? The visual and musical arts offer opportunities in attempting this challenge: perhaps algorithms can be designed like skyscrapers, and criticism can be defined by perceptually-enabled interaction? Malina has created a phrase he calls the "crisis of representation" (Malina 2012), which characterizes the problem. SEAD Disciplines tend to be segmented using representational norms. The norms should be challenged by exploring new representations.

Game Experiences

The need to inform the general populace of computing can result in several different approaches; however, I suggest one specific approach based on interactive game technology. This approach involves exploring new representations for computing artifacts. I propose learning computing

through game experiences. Consider, for example, two game experiences initiated by the same author: Minecraft and 0x10c (Notch 2012). Minecraft is a "block game" where blocks are mined, and a subculture of Minecraft has resulted where players use raw game materials to construct digital circuits (Minecraft 2012). The emerging game 0x10c is centered on the use of programming a virtual machine (DCPU-16) whose function serves as an in-game experience involving piloting and controlling a space ship. Aspects of computing, rather than being used to create games (i.e., writing game code), are instead used as virtual environments whose experiences involve learning computing. In Minecraft, one can create circuits out of virtual blocks and in the planned 0x10c, one can program a virtual computer for steering gameplay. The proposed goal is not to learn computing by authoring game code, but to leverage game-based social networks, culture, and gameplay as means for introducing computing concepts.

Aesthetic Computing Class

Many games and mods of those games can be used to create experiences that reinforce, or introduce, formal concepts found in computing. I have taught a class at the University of Florida for the past decade called Aesthetic Computing (AC 2012, ACP 2012). The purpose of the class is to broaden the representational possibilities for formal structures found in computing by using the arts and humanities as guidance. The products from this course have evolved over the years, and this past year, students used games and game engines to represent computing constructs such as data, equations, and code. One of the Spring 2012 class projects (Tadayon, Wilson, and Vo 2012) involved a simple Petri net using Minecraft features including dispensers, eggs, lava, and pistons. Figure 1 shows a side view of the Petri net. The redstone blocks in Minecraft are necessary to model message propagation needed for simulation modeling of the Petri net.

Figure 1: Side view of Petri net in Minecraft (from Tadayon, Wilson, and Vo 2012)

Using games as a means for teaching computing concepts can be seen as a form of serious gaming, although in this proposal, no new games are proposed. Instead, learning is facilitated by starting with existing game cultures such as the one around the game Minecraft. The opportunity for leveraging these cultures and adopting game-based materials as raw elements for novel representations of computing constructs separates this proposal from other work. The root idea is not new, as formal structures such as universal computers and calculators have been constructed from Legos and Tinkertoys and numerous other natural or engineered materials. The proposed curricular improvement is to build upon the past use of toy objects for constructing analog computers and to 1) broaden this concept to allow for multiple formal constructs (not only arithmetic units and universal computers), and to 2) employ game cultures, such as Minecraft, as a basis for exploring new representations of formal constructs. The assumption is that if players are drawn into subcultures of games, this sociological phenomenon can assist in learning new concepts that are contextualized within those subcultures. It is feasible to take this approach in learning any new concept, however, this proposal is based on computing concepts as a starting point.

Stakeholders and Recommendations

The primary stakeholders in this proposal are 1) the students who learn formal concepts of computing, 2) educational researchers who wish to explore the effectiveness of new representations on learning, 3) agencies concerned with learning (e.g., MacArthur Foundation, Bill and Melinda Gates Foundation, and the National Science Foundation), and 4) game authors and companies. Classes can be co-taught by SEAD discipline-specific teachers who wish to explore representational challenges outside of the norm: building algorithms and programs rather than writing them, and simultaneously exploring their rhetorical values within game cultures. Specific recommendations include:

1. Constructing educational scenarios for game-based experiences, including learning objectives for computing concept learning.
2. Creating a transdisciplinary SEAD social network, and workshop, for solidifying goals and outcomes for this approach.
3. Defining social science and education-based formal methods of assessment for measuring learning and motivation, and for studying game cultures and their players.
4. Exploring the broader impact of this approach on non-computing learning objectives in the SEAD disciplines (e.g., physics, social science, history).

References

AC 2012. Aesthetic Computing 2012 Course. http://www.cise.ufl.edu/~fishwick/ac/2012/
ACP 2012. Aesthetic Computing Best Project Videos.
http://www.cise.ufl.edu/~fishwick/ac/2012/bestproj.html
Fishwick, P. A. 2012. Aesthetic Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "Encyclopedia of Human-Computer Interaction". Aarhus, Denmark: The Interaction-Design.org Foundation. Available online at http://www.interaction-design.org/encyclopedia/aesthetic_computing.html

Malina, R. 2012. Commentary on: Fishwick, Paul A. (2012): Aesthetic Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "Encyclopedia of Human-Computer Interaction". Aarhus, Denmark: The Interaction-Design.org Foundation. Available online at http://www.interaction-design.org/encyclopedia/aesthetic_computing.html

Malina, R. and Strohecker, C. 2012. http://seadnetwork.wordpress.com/sead-white-papers-steering- committee/Minecraft 2012. Redstone Circuits. http://www.minecraftwiki.net/wiki/Redstone_Circuits

Notch 2012. 0x10c Space Game Wiki. http://www.the0x10cwiki.net/0x10c_Wiki

Tadayon, R., R. Wilson, and P. Vo. 2012. Petri Nets in Minecraft. Accessed June 8, 2012. http://www.youtube.com/watch?v=sUR3xqPWU1I

Anti-Disciplinary Collaboration

Coordinator: Felipe Fonseca

Karla Brunet, Luciana Fleischmann, Maira Begalli, Yasodara Córdova, Orlando Silva

Collaboration has a number of different, sometimes contradictory, meanings. It is often referred to as something which allows one to overcome the restrictions of a single discipline in order to achieve disruptive practices. That kind of collaboration is meant to foster the development of projects which will have a strong impact on the world, to create a great future that neither isolated discipline would be able to produce. This paper intends to explore a slightly different perspective on collaboration. We are inspired by emergent practices including those of the Brazilian MetaReciclagem network, which celebrates it's tenth anniversary in 2012, with hundreds of members spread across all regions of Brazil. Whilst openly contrary to becoming a formal institution (which would involve submitting permanently to this or that hierarchical context) and expressing heavy criticism on both academic and artistic circuits, MetaReciclagem is regarded as having influenced experimental production both in academia and the arts, as well as in innovative public policies implemented in recent years. We argue that one of the fundamental reasons of this creative potential and strength is precisely the fact that disciplines are usually ignored or disregarded in this network's everyday practice and decision making processes.

In 2011, some of the members of MetaReciclagem decided to experiment in a new context: creating and organising an academic conference whose goal was to create bridges between science (in particular, environment related sciences), appropriate technologies (traditional knowledge and vernacular innovation), arts and experimentation, and collaborative networks. The first Cigac (International Conference on Collaborative Environmental Management) took place in June 2012 in the countryside of Paraíba, a state in northeastern Brasil marked by harsh drought and poverty. The Conference was an experiment in its own right, mixing more conventional formats such as the presentation of papers and posters with alternative approaches like panels, open conversations, short courses, workshops and a temporary hacklab.

In this paper, as well as presenting collaborative anti-disciplinary practices in MetaReciclagem, we will also be discussing the many challenges faced in making Cigac happen, and some insights on its relation to the open-ended informal innovation in MetaReciclagem. By doing that, we would like to shed some light into the manifold possibilities of cooperation between different kinds of collaborative practices, while paying attention to potential conflict and dissent likely to appear in such conditions. Such tension in itself will be analysed as fertile ground for anti-disciplinary collaboration.

British Heart Foundation Centre of Research Excellence
(BHF Core) Artists Residency Programme

http://wp.me/P2oVig-es

Coordinator: Chris Fremantle

Advisor: D. Urquhart

We propose to submit a White Paper focused on the British Heart Foundation Centre of Research Excellence (BHF CoRE) Artists Residency Programme which has been delivered over the past 3 years at the Queen's Medical Research Institute, University of Edinburgh in partnership between BHF CoRE and Edinburgh College of Art, in particular the Art, Space and Nature MFA.

It is well understood that the disciplines of art and design and of the biomedical sciences have different forms of knowledge, methods of research, types of evidence, etc. The residency programme has not sought to conflate or erase these differences, but rather to support and value both fields of research and practice.

The paper will outline work done to date, and will draw out key challenges and opportunities through in depth semi-structured interviews with the some of the participants, both artists and scientists. In relation to the suggested theme our aim will address the question "So just what do we need to advocate for?"

Key areas of the programme work that we will draw on in addressing this question will be:

The structure and process used to introduce artists and biomedical researchers;

A consistent selection process, developed with the assistance of Art, Space and Nature staff, has been used for each of the three years of the programme. All artists on the Art, Space and Nature programme were eligible to submit a proposal. All students attended a day of presentations at QMRI by given by a wide range of researchers. In response there was a second day of reciprocal presentations by artists on the Art, Space and Nature programme. These covered their own practice to date and highlighted areas of research at QMRI that were of interest to them. Residencies ended with presentations followed by Q&A sessions involving the wider group of researchers and artists.

The development of understanding of both artists and biomedical researchers participating in the programme.

We will focus on the trajectories of understanding of the different working processes and objectives. This will be drawn out through semi-structured interviews. One of the issues for interdisciplinary working is the achievement of 'disciplinary adequacy', i.e. sufficient understanding of each other's disciplines.

The White Paper will draw on the Leonardo Journal (e.g. Foster, 2011) as well as literature on interdisciplinarity (e.g. Repko, 2008), collaboration (e.g. Kester, 2011; Fremantle, 2012) and existing reports already identified by SEAD. These will provide a critical framework.

References:

Foster, C. (2011). Three Colors: Coomassie Brilliant Blue, Sudan I and Somalia Yellow. Leonardo Journal (44, 1)
Fremantle, C. (June 2012). Reflections on Collaboration. 24 August 2012.http://www.an.co.uk/publications/topic/2228109
Kester, G. (2011). The One and the Many: Contemporary Collaborative Art in a Global Context. Duke University Press, Durham and London.
Repko, A.F. (2008). Interdisciplinary Research: Process and Theory. Sage: Los Angeles, London, New Delhi, Singapore

DIWO (Do-It-With-Others): Artistic Co-Creation as a Decentralized Method of Peer Empowerment in Today's Multitude

Coordinator: Marc Garrett

Furtherfield originally created the term DIWO in 2006, to represent and reflect its own involvement in a series of grass root explorations between artists instigating critically attuned, mutual engagements, shifting curatorial and thematic power away from top-down initiations into co-produced, networked artistic activities; it has now become an international movement much bigger than we imagined.

The practice of DIWO allows space for an openness where a rich mixing of components from different sources crossover and build a hybrid experience. It challenges and renegotiates the power roles between artists and curators. It brings all actors to the fore, artists become co-curators alongside the curators, and the curators themselves can also be co-creators. The 'source' materials are open to all; to remix, re-edit and redistribute, either within a particular DIWO event or project, or elsewhere. The process is as important as the outcome and these mutually respective engagements work as forming relationally aware peer enactments. It is a living art, exploiting contemporary forms of digital and physical networks as a mode of open praxis, as in the Greek word for doing, and as in, doing it with others.

This study investigates why these critically engaged activities were (and are) thought of as essential nourishment not only for 'individual' artists, but also as an effective form of artistic collaboration with others, and to a wider culture. It critiques the differences between 'collaborative' trends initiated by established art and design institutions, the creative industries, corporations, and independent projects. It explores the grey areas of creative (idea) control, the nuances of power exchange and what this means for independent thinking artists and collectives working within collaborative contexts, socially, culturally and ethically. It also asks, whether new forms of DIWO can act as an inclusive commons. Whereby it consists of methods and values relating to ethical and ecological processes, as part of its artistic co-creation; whilst maintaining its original intentions as a decentralized method of peer empowerment in today's multitude?

Data Sonification; An Emerging Opportunity for Graduate Music Schools to Expand Research in an Art and Science Collaboration

http://wp.me/P2oVig-et

Coordinator: Scot Gresham-Lancaster

As the size of data sets grow larger and larger, they are becoming more difficult to investigate for unique patterns and anomalies. Most tools for this sort of investigation are visually based. There is an opportunity with additional tool of sonification to enhance the ability of researchers to observe new relationships in data sets. A synthesis of sight and sound increases the likelihood of exposure of new features and interconnections hidden in more standard "visual only" modes of investigation. The creative application of musical understanding of acoustics, physical modeling synthesis, harmony, even musical style enable the use of sonification to become part of the curriculum for graduate level study not only in research labs but in music conservatories and schools world wide. The bridge between musical practice and sonification is just beginning to be realized, but the potential reward is great. This White Paper proposes to layout some basic premises that music and sound art departments should consider when introducing the concept of sonification tool set for scientific discovery. The aim is to encourage new resources that will leverage the rich history related to music and sound design to create new tools and paradigms for the expanded investigation of ever growing and varied data sets across a wide range of disciplines.

Citizen Art and Science as Enablers of New Public School Excellence Initiatives

http://wp.me/P2oVig-7U

Coordinator: Molly Hankwitz, PhD

Introduction

A growing concern among citizens is a set of environmental issues which threaten the livelihood of the planet. These issues range from climate change and its influence upon polar ice cap melting, to surface air temperature warming and fire hazard; to water conservation, the state of the oceans, the impact of landfill and plastics, and the effect of toxins upon human and animal food. The "green" movement in Northern California, and indeed, across the USA has manifested in future planning strategies and programs of organizations from the US Green Building Council to major newspaper production, supermarkets, and public school curriculum initiatives.
Effective Special Programs

One area of citizens' environmental concern which has grown rapidly has been the development of programs such as the greening of school campuses, citizen science projects to monitor environmental disasters, grassroots mapping projects and open science platforms. These initiatives have, in turn, influenced principals and teachers to produce quality elementary, middle and high school curriculum which crosses over between art and science involving studies in composting, rainwater catchment, botany, solar energy use and design, farming and environmental science through the making of paper and other useful materials, recycling food waste and trash, utilizing waste in sculpture and collage, or monitoring water and sun as part of a poetry and science program. In some cases, entire school buildings have been designed to produce interest among students in the green building functions of their own energy and water efficiency. Curriculum has left the school and moved into the neighborhood where engineering and architectural design are being taught through storefront workshops to young people.

Roadblocks and Inhibitors

This interdisciplinary learning, which does not remove the student from knowledge of art and science, but which places the student in direct contact with critical processes for learning, i.e. experimentation, trial and error, and documentation is a fertile arena for the consideration of ongoing curriculum development in the sciences, and the deployment of science into public education. It is not without stumbling blocks, however. For one, public funding for the arts and arts education is low. Secondly, science education is frequently geared toward expedient fulfillment of state curriculum standards and proficiency testing, rather than exploration or cross pollination of new ideas. Educators only have so much time to expand curriculum and still engage state requirements effectively while standardized testing precludes the positive effects of learning arising without quantifiable outcomes and tends to harness student power in the form of multiple choice, memorization, and wrote learning.

Moreover, impediments to career paths start young. Gender imbalances and lowered performance among minority schools may mean contexts where both art and science are

considered less critical than are other basic skill sets, or the culture taught may not register adequately with different groups. This in turn may reinforce divisions in society that persist in the social stratification of the arts and sciences and in higher education. What is critical, however, for the implementation of art projects with which to learn science and science projects with which to do art is knowledge that addresses these social inequalities outright as the basis of design/art/science/engineering learning.

For instance, data on drinking water quality in neighborhoods or regions, suggests increased likelihood of health damage to minority populations. (Gross, 2012)This data can mean a great deal to those affected by it, providing it is known, understood and responded to. The central question for curriculum and initiative practitioners is: how to ensure all students engage with meaningful information, know how to use information and data, and are able to address, analyze, record, or sustain relationships to and solutions for its impact upon their communities? The question becomes, then, how are university-led initiatives for the arts and sciences to be meted out in public education and how does the culture of art and science knowledge ensure its community-based relevance for all students?

Synopsis

This paper examines three primary strands of interdisciplinary processes with respect to their integration into communities of learning, and recommends actions for their sustainability. Firstly, it examines how students best engage with contemporary social issues in the arts and sciences. Secondly, it suggests potentials for cross-cultural developments between art and science and possible partnerships within the educational spectrum which engage with the underserved. Thirdly, it encourages collaborations between art, design, engineering, scientists, science educators, and school systems primarily in the arena of the environmental sciences and futurology; where issues of sustainability, accurate analysis of contemporary science, environmental systems and their corollary in art can be most impactful and useful. It posits both mentoring and open educational platforms as a central condition of new knowledge production and effective interdisciplinarity in the arts and sciences.

Gross, Liz. Pollution, Poverty, People of Color: No Beba la Agua. Don't Drink the Water in Environmental Health News, Environmental Health Sciences, 2011.www.environmentalhealthnews.org

Environmental Equity: Enabling Excellence in Media Art and Science in Under-Served Communities

http://wp.me/P2oVig-ke

Coordinator: Molly Hankwitz, PhD

Environmental sustainability, accurate analysis of contemporary environmental systems and regard for health information have special relevance for communities bearing the brunt of environmental damage and long term health risks. Recent tendencies in data visualization, and futurology show citizens' art, citizens' science and community-based innovation in new technologies at the very center of knowledge production for these fields. This 'diy' media/research, flexible and responsive to community issues and concerns, using open platforms, new technologies, and complex collaborations between experts, citizen scientists, artists, and others, successfully bridges gaps and inequities in the fabric of public learning.

From examining numerous contemporary models, we must consider how media literacy and media-making, in the context of environmental art and science, might grow to benefit the underserved. Media literacy, critical thinking, and community-based media are, after all, effective channels through which communities engage with, participate in, and produce their own history. Art and science are disciplines which link all citizens' to the value of diverse and very personal information. When coupled with digital literacy to support the work of receiving, recording, and expressing collaboration, communities have a cultural voice and considerable empowerment to resist.

This paper is driven by these exciting new approaches to and tendencies in art and science. On the one hand, by the new fields developed for gathering "dynamic information" (sentient, environmental) and two, by the primacy of "media literacy" as a fundamental component of human emotional health, education and welfare. It is also driven by apparent cultural inequities where digital means are concerned and its' primary focus is to articulate that crucial gap.

Interdisciplinary collaboration in media literacy, media arts, and science is capable of expressing both critical thought and the imbalances in thought and action from which under-served communities suffer with respect to the environment. It is essential to give voice to communities in need and to lift them out of simple "job training" trajectories, to explore new ideas, forms of expression and skills with which to engage in broader dialogues.

Emergence of New Institutions for Art-Science Collaboration in France and Comparison of Their Features with Those of a Longer Established One

http://wp.me/P2oVig-k8

Coordinator: Christian Jacquemin (LIMSI-CNRS & University Paris-Sud)

Possible contributors: Nathalie Delprat – to be confirmed (LIMSI-CNRS & University Pierre and Marie Curie), Jean-François Depelsenaire or Emmanuel Mahé – to be confirmed (ENSAD Lab), Hugues Vinet (IRCAM), Roger Malina – to be confirmed (IMERA), Eliane Sausse – to be confirmed (Atelier Arts-Sciences)

Interestingly, there has been several recent initiatives in France to promote collaborations between artists, scientists, designers, and engineers. They have emerged from the serendipitous collaborations between institutions which shared common interests for this domain, or from local non-standard initiatives. Contrary to the now well-established and internationally acclaimed IRCAM research laboratory, most of these local initiatives are small, are only supported by small to medium-size budgets, and have small human resources, made mostly of part-time personnels who spend the rest of their time on other activities.

The purpose of this publication is to analyze the conditions of emergence and development of three recent institutions in arts/sciences collaborations: ENSAD Lab (a research laboratory in an applied arts school), l'Atelier Arts/Sciences (a collaboration between a National Theater and a large industrial company operating in nano-technologies), and VIDA (a research theme on arts/sciences collaborations in a Human Computer Interaction research laboratory). We will discuss their mode of funding, support, and their organization in comparison with IRCAM and try to highlight the contributions, strengths, and weaknesses of these newcomers to the area of arts/sciences collaborative research. In addition to general considerations, we will illustrate the dynamics of these institutions through some of their past or current projects.

Mapping Space: Geographical Information Systems for School Education

Coordinator: Anu Joy

The paper explores the potential of Geographical Information Systems as an educational tool that can address a range of spatial questions in the school classrooms and support teaching and learning of diverse school subjects ranging from History to Social Sciences to Natural Sciences. GIS has the potential to integrate a vast variety of information and its geo spatial visualization. Thus a single tool can be used to teach diverse topics and various aspects of a geographical location such as regional peculiarities, cultural resources, socio-economic realties, historical sites, biodiversity, land and water resources, settlement patterns, bio-physical and agro-ecological characteristics, stars that appear on the night skies, rainfall and temperature data and many others. The process of creating maps and data bases of familiar everyday world can enhance children's understanding of geographical locations, sense of space and entities in it, direction, visuo-spatial thinking, observational, and cartographic skills. It can also help children to build connection with nature and to their own localities, spaces and entities in it, which can motivate children to take initiative to conserve their local environment, by knowing the resources available (physical, historical and cultural) and how their practices, usage and interventions can create an impact.

Despite this potential, and availability of computer in schools and free GIS software, the use of modern day tools and techniques such as GIS is practically absent in the Indian school classrooms towards teaching and learning. Indian school curriculum in the subject area of Social Studies pays attention to map reading (world map, political maps, geophysical maps etc.), but little attention is paid to the process of creating maps. Map reading and map making involves different skills. Map making involves active visualization of space, directions, proportions, routes, landmarks, buildings, trees, placing the map maker also on the map, etc. The concepts, techniques and methods of map making do not constitute children's regular school curriculum and this necessitates the design and evolution of a pedagogy and content for introducing tools of map making as part of school learning.

This paper presents the details of the content and pedagogy developed together with the tools and resources used for a summer workshop conducted with 18 school children from grade IV to grade VIII, to introduce them to the tools, techniques and concepts of mapmaking. The workshop focused on directing children to discover and understand the significance of their familiar everyday world and immediate surroundings for map making. The mode of instruction included activities such as drawing maps of familiar locations and route maps, familiarizing with software tools, field walks, navigating with maps and GPS, and collecting data to create maps that highlighted environmentally significant aspects of a campus. During the initial sessions, children drew maps of small areas such as their home and its surroundings, school locality, route map from home to nearby bus stop/school etc. Later children were guided through two projects to track and create maps using a set of icons that represented buildings, landscaping, biodiversity and renewable and non renewable energy sources of a 5.75 acre campus of a research institute that brought together the concepts learned, use of computer, software tools and techniques.

Children identified and geocoded, a total of 363 trees which belonged to 82 different species, 69 genera and 33 families. Each child chose four types of trees and mapped their locations in the campus to represent it on the map. They used GPS to track the relevant entities and then load the information on to Google Earth and view the points on the background of satellite image. The workshop also introduced the following concepts through children's seminars and groups discussions a) Maps and its significance for everyday life b)Locations, directions and land marks c) Elements of map making d) Map scale and proportions: Large scale and small scale maps e) Reading maps: district maps, state maps, world maps, and using globe f) Symbology, Legend box and map features g) Latitude and longitude h) Techniques of map making: from traditional to the modern i)Types of maps j) Surveying and mapping k) The story of great arc l) Aerial maps and mapping from above and m) GPS and GIS.

The hand drawn maps of 18 children provide insights into how children visualize a geographical space and transform the three dimensional visualization to that of two dimensional. Also how children perceive and represent their everyday familiar world through symbolization, abstraction and generalization?

The activities, tasks and projects conducted during the workshop with children shows that a learning module of the above kind can provide an authentic context for an inquiry mode of learning. Children reached at their own learning independently through discussions, seminars, projects, activities and working in teams. The workshop did not focus on specific learning outcomes, rather encouraged diversity in outcomes among children of different age group based on their ability and pace. The learning outcomes were assessed while performing the tasks and in practical contexts that reflected the contexts and usage of concepts in appropriate ways. What was interesting to note was even the junior children who participated in the workshop were able to create maps and database, use GPS and software tools, apply relevant concepts and enhance their understanding of space, of trees and plants etc., where senior/ more knowledgeable children acted as capable peers who motivated and guided learning. This shows to us that a heterogeneous group of children of mixed ability and age can create a rich learning context and produce better learning outcomes.

Hackteria.Org: Nomadic Science and Democratized Labs

http://wp.me/P2oVig-ea

Coordinator: Denisa Kera, National University of Singapore
Marc R Dusseiller, dusjagr labs & hackteria, Switzerland

Links:
http://hackteria.org/

The "Hackteria | Open Source Biological Art" initiative started in February 2009 when Andy Gracie, Marc Dusseiller and Yashas Shetty initiated a new model of interdisciplinary cooperation during the "Interactivos 09 Garage Science" workshop at Medialab Prado in Madrid. Instead of using the predominant artist collective model, they intentionally decided to use the hackerspace model of cooperation in interdisciplinary projects. This model is based on the idea of co-working in alternative and independent, temporal spaces rather than building stable structures, such as art laboratories and (new)media centres, or looking for residencies in science laboratories etc. This model also rigorously uses wikis and "work in progress" documents instead of well documented and presented final artworks, which tour various festival and exhibitions. The mode of presentation are workshops involving various people in groups in various parts in the world and sharing know how on what works and what does not work.

The Hackteria network managed to expand over the years to more than a dozen members and over 40 projects from life science to nanotechnology, molecular gastronomy to agriculture. It involves scientists, artists, engineers, hackers, science communicators, educators, and philosophers, who mainly identify with tinkering as an approach to knowledge rather than art per se. The "open end" workshop style of collaboration encourages collaborations between scientists, hackers, and artists, which combine various expertises, rather than in creating some final work. The wiki platform proved to be an effective model of communication but also organization, which supports both the maker, DIY ethos, but also the global network of members based in very different locations around the world (India, Spain, Switzerland, Slovenia, Singapore, and Indonesia). The art and design practices were from the right beginning inspired and modelled after the tinkering, hands on approaches based on open source software and hardware tools, which are common in hackerspace culture. In a typical Hackteria event, the interest in experiments and science protocols goes hand in hand with interest in creation of low tech equipment, which is also useful for supporting research in developing countries, such as Indonesia or Kenya.

The usual start of any Hackteria workshop is related to an attempt to create a lab in a place, where there was no access to laboratory infrastructure before and to demystify, what is happening in the science labs in front of some new public. It can be a gallery space, like in the NanoŠmano project, which happened in collaboration with Stefan Doepner (Cirkulacija 2) and Kapelica Gallery in Ljubjana, Slovenia, or it can be the a mobile food truck on the streets of Yogyakarta, which was a project started with the House of Natural Fiber and the HONFablab, in January 2012, pushing the limits of how to democratize science. The interest in building alternative science laboratory is related to the genealogical interest of the group in tinkering,

16.century culture of mechanical artists and alchemists, which seems to be going through a certain revival. Science laboratories used to be places, where the noble gentlemen and the members of various learned societies would go to experience how new knowledge is produced and to discuss the dangers and opportunities this brings to the society and humanity itself. Science laboratories today are highly contested zones, where politics and profit making rather than pursuit of knowledge play an essential role and form our future. The romantic ideal of gentlemen science, which started the whole scientific revolution back in the 16.century, has very little in common with the reality of today's militarized and bureaucratized spaces, which are designed in order to make any exchange of information and knowledge with the outside world and lay people impossible. These spaces are defined not by curiosity, but by security protocol. Any reflection and decision making are just political negotiations between economic, political, and NGO elites, joined by professional science communicators, PR specialists, and lawyers as witnesses and mediators of the process.

This is part of the reason, why Hackteria starts its workshops with empowering groups to build their own labs from low tech and hacker equipment they can find around. In Indonesia the work started in the flea market where the group purchased old scanners, webcams, and similar tools, which were transformed into a microscope, sterilization equipment, or even added as a "retro-modernist" decoration. Democratizing science by building laboratories on unexpected places and by performing protocols with unexpected equipment is a type or partially comical and partially serious performance. It is a "proof of concept" that research is possible in such unexpected place, but it is also about exploring the artistic aspects of the common "scientific" performances of protocols.

This interest in building alternative and nomadic labs is one of the hallmarks of Hackteria projects. It lets common citizens and participants in the workshop to understand the limits and possibilities of any laboratory equipment and to develop a critical, but also creative and relaxed attitude towards science. Most citizen science activities are too serious nowadays. They all usually perceived and defined by data collections or screensaver activities, which everyone hopes will improve the professional scientific research and popularize science. It is believed that ordinary citizens can easily learn how to spot and describe a bird, a bat or a flower, and they will feel better when they can perform this care for biodiversity and their environment. Some even take part in a gamified, puzzle solving activities, so they waste their time on something useful for science, like recognizing the connection between neurons or protein structures. None of these activities however involves the citizens directly in laboratory practice and generation or probing of scientific knowledge or the decision making and policy of some emergent scientific field.

Hackteria projects offer an interesting precedent in this respect. They not only involve the citizens directly in the use of laboratory equipment and some protocols, but they let people build their own, low tech and cheap equipment. This collective hacking of consumer electronics into lab equipment pushes the citizen science and DIY activities to serve a whole new purpose: they democratize science by demystifying its tools and protocols and showing its limits. Hackteria projects demystify and democratize science by creating cheap microscopes from hacked game webcams, which enable such equipment to be used anywhere in the world. They also show how nanotechnologies are part of our everyday life and reality, thus enabling everyone to have an

informed opinion on such matters, just like a Victorian gentleman would do in some of his friend's house lab in the 17.century.

Hackteria nomadic labs present a new trend in the hackerspace, maker, and DIYbio movement. They are organizing more transient zones and mobile R&D workshops rather than seeking for a stable space. Connecting travelling and hacking has an interesting genealogy going back to the Greek work "theorein" (theory, science, knowledge), which meant simply a diplomatic mission to another Greek cities in order to observe some festivities. Science and knowledge need to be exposed and performed in various new groups, customs, and environments, in order to fully understand their possibility and meaning. Growing number of alternative R&D projects are moving away from the static, location-based model, in which the goal was to setup a co-working space or community lab, to a nomadic and mobile models, allowing greater intensity of experiments and networks between various technologies and communities.

The extreme case of such mobile and nomadic kitchen-lab was tested on the streets of Yogyakarta (Indonesia) in January 2012 as a model for future science – society interactions. The mobile push carts, angkringans, and similar food trucks, which are omnipresent on the streets of Indonesia, offer an ideal setting in which to revive 16th.century origins of science in the alchemist's kitchens and to remind us of the artisans' experiments, which always involved not only observations, but also tasting. The Do-It-Yourself (DIY) and Do-It-With-Others (DIWO) approaches in citizen science projects are embodied in the street food culture of Indonesia, which could serve as a model for public participation in science initiatives. Science simply needs to go to the streets, it needs to taste and to involve people in a visceral and embodied level in order to provide a real participation and a more democratic policy model. These food laboratories on the streets of Indonesia are keeping the idea of citizen science alive and tasty because they let everyone to be part of the cooking and to provide feedback on the process, an immediate and honest peer review process. They also allow people to interact with each other while the meal is prepared and consumed on all the important matters for the community.

Indonesian angkringans are the perfect mobile labs and model for citizen participation in science that can truly democratize the decision process. We need mobile labs, wearable labs, etc. to bring science experience back to its roots, which is our curiosity about the world around, ability to digest and transform all energy into something creative. With this project, Hackteria tried to reconstruct the idea of a science back to cooking, to remind this culinary primate, homo sapiens, that tasting and probing the world around and sharing knowledge with others is in our nature. It was also a tribute to the alchemists, who made the first connection between cooking, distilling, understanding and playing with the world in their kitchen labs. It was also a tribute to all the angkringans and mobile cookers in Indonesia that offer such powerful metaphor for citizen science.

Hackerspaces and alternative citizen labs, such as Hackteria, are becoming important sites of translation between scientific knowledge and technological innovation produced in the traditional and official labs and the everyday interests, practices, and problems of ordinary people around the world. These translations are happening through collective and global tinkering, building and testing of prototypes in various settings and contexts with more inclusive agenda of involving anyone, who is willing to tinker, learn, and share knowledge. The resulting,

disruptive prototypes are not simple cases of disruptive innovation and technology, which are waiting to be scrutinized by a government and regulatory bodies and then utilized by some startup company or a large corporation. They embody new models of interaction between research, design, policy, and adoption, which happen through the engagement of intermediaries and which allow user adoption to become a form of collective hacking, tinkering, and deliberation happening simultaneously and on an unprecedented scale.

Artistic Research Collaboratives in Science, Engineering and Technology

Coordinator: Kanta Kochhar-Lindgren, Ph.D.

Artistic Research Collaboratives in Science, Engineering and Technology, ARCiSET is an international sci-art research and action project designed to bring local, national and international communities together for the purposes of learning from each other. ARCiSET on Water: Delhi/Cochin will bring together participants from India, the United States, Hong Kong, and Indonesia to investigate the links between arts practices, science, technology, cultural diplomacy, and water as a material resource and carrier of symbolic value, particularly within the context of rivers. Subsequently, the participants will return to their respective locales, and, in small teams, develop follow up projects that disseminate the processes and the work of the project in order to localize it further. This project will generate internationalization for and between the respective partners that can also lead to new university and community sci-arts initiatives.

In an effort to collaborate on how to generate new forms of communication, arts, design and technology across communities in Delhi and Cochin who are struggling with these water issues and to create a model for generating best practices in the field of arts diplomacy this project – ARCiSET on Water: Delhi/Cochin– will partner with local agencies in science, engineering, law, and the arts to explore how we can use arts and design processes as methods of thematic inquiry and problem-solving in a cross-cultural context:

a) To catalyze new forms of cultural diversity and cultural diplomacy that prepares artists and their local communities to engage in global citizenship, with a specific focus on India, particularly in a trans-Pacific context, and

b) To create a model for generating best practices regarding university and community sci-arts initiatives in the context of the global university.

New methods of discourse and opportunities for artists across our local and global communities to engage in the conversation over water, and specifically in India, are more important than ever. These methods will allow communities to: 1) tell their local and global stories about water; 2) generate new social, political, and cultural dynamics around water practices; and, 3) find ways to bridge the science, art and religion divide that, unmitigated, haunts our water problems and limits our capacities to find new solutions fast enough.

Climate change and pollution are inextricably intertwined with global economics and the widening gap between wealth and poverty, along a North/South axis. As world economic power shifts from Europe and the US to China and India, how does this scenario play out at local levels? The focus on creating new value for water is both practical and symbolic, since care for rivers is vital for sustaining life and culture.

Feeling Your Way into STEM

Just over a year ago, I discovered an object that changed my world. It's called a crocheted hyperbolic plane. A hyperbolic plane is a mathematical object, and a crocheted hyperbolic plane is a yarn model of that object, made with some simple crocheting.

In formal terms, a hyperbolic plane is a surface of constant negative curvature—sort of the opposite of a sphere, which is a surface of constant positive curvature. If you find it hard to imagine, you're in good company; until the 19th century, a hyperbolic plane was thought to be an impossible object. The first crocheted hyperbolic plane was made by computer scientist and mathematician Daina Taimiņa, using the skills she had been taught as a girl growing up in Latvia.

My relationship to math had been one of misery and torment, from grade school all the way through graduate school. Hyperbolic crochet has turned my relationship to math upside down, and has shown me a very different route into math and computing that can help to avoid—and even reverse—the anxiety and pain that some of us experience as we move through the math education system in the U.S.

Crocheted hyperbolic planes have many layers of meaning, moving well beyond what we normally think of as math. As "evocative objects," they are an elegant and engaging gateway into such topics as systems theory (illustrating emergence), the beauty of math, symmetry, and pattern (for those who do not see beauty in school math), algorithms (the crochet instructions are

an algorithm), gender (fiber arts in the U.S. today are a comfort zone for most women), comfort and recovery (our research study shows a reduction in math anxiety), and 3-D cognition and visualization (a skill lacking today in many college students), and the role of emotion in learning (people love these things!)

Hyperbolic crochet can change the world. How?

- Reimagine math and computing curricula for formal and informal settings
- Leverage "thinking with things" and maker culture in learning
- Use existing social networks of knitters, weavers, and other fiber artists to spread an alternative view of math and computing
- Workshops to reduce math anxiety in teachers, parents, and students

How I Became an Art[Scient]ist: A Tale of Paradisciplinarity

Coordinator : François-Joseph Lapointe, Université de Montréal

In 1992, I earned a PhD in evolutionary biology. In 2012, I obtained a PhD in dance. It took me 20 years to become an art[scient]ist. In the process, I have encountered many pitfalls and roadblocks, but also greatly benefited from remarkable opportunities. In this paper, I reflect on my own experience to present an insider's view of artscience, the rare tale of a scientist venturing in the field of art. I propose a roadmap for achieving paradisciplinarity; the parallel and symmetric practice of scientific and artistic activities. Namely, I present a list of sufficient and necessary (desirable) conditions for the making of a true paradisciplinary art[scient]ist. This list [incomplete] includes: give scientific talks at arts conferences; show art/performance works at scientific conferences; obtain grants from scientific and arts agencies; obtain joint faculty appointments in science and art departments; teach science to artists and art to scientists; supervise graduate projects in artscience; publish in art, science, and artscience journals (Leonardo). This paper is not about collaborative artscience projects involving scientists and artists working on a common subject/object, it precisely concerns individuals who want to become successful art[scient]ists with dual careers, both as working scientists and performance/exhibiting artists.

Interactions among Scientists/Engineers and Artists/Designers as a Means of Encouraging Unique Perspectives on Today's Challenges

http://wp.me/P2oVig-as

Coordinator: D.L. Marrin, Ph.D. (scientist), Water Sciences & Insights, USA and Fundación Somos Agua, México

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Gregory Shinn (designer); GRS Landscape Architects, USA

The technical and societal challenges we face at the dawn of the 21st century will likely require not only the continued development of 20th century technologies, strategies, and educational approaches, but also more fundamental shifts in the way that we perceive and relate to our world. Many of the significant breakthroughs in the arts, sciences, and design fields have arisen, not from modifications of standard or existing views, but from fundamentally different ways of perceiving the world—whether through the senses or the intellect. Artists/designers and scientists/engineers are uniquely positioned via their respective training and creativities to view the world in different, but complementary, ways. A virtual symposium held in November 2011 brought together people from diverse fields working with water, which is perhaps today's most critical resource.1 Interactions and presentations highlighted both opportunities and challenges, which included [1] developing a common language (verbal or otherwise) for communicating across disciplines, [2] utilizing art or artistic portrayals (e.g., fractals, flow forms) to describe or investigate nature, and [3] incorporating scientific perspectives into the creations of artists and designers who reach people in innovative ways and devise practical systems and structures.

This proposed White Paper will explore art and design as a means of expanding the ways in which scientists and engineers describe and investigate the world, as well as the ways in which scientific perceptions influence the portrayals of and designs for the world. Water and water-related issues have proven to be a useful in this regard because they are common to so many diverse disciplines. The goal of sharing interdisciplinary perceptions to reveal more effective ways of approaching or representing our challenges will necessarily face the hurdle of effective communication among practitioners. The jargon, mathematics, and views of science/engineering must somehow mesh with or connect to or the images, sounds, or forms art/design in order to enable productive interactions and the transfer or melding of perspectives. Patterns, rhythms, and geometries are common to the work of both groups and may represent a productive avenue for bridging the language difference. A number of different options for addressing language and communication obstacles will be considered.

1 International Symposium on Aqua Science, Water Resources and the Arts (3-5 November 2011), D.L. Marrin, Organizer. http://www.isaswr.com

Prospective Interfaces Between Art + Science + Technology + Society, In, and from, the South Cone Pacific

Coordinator: David F. Maulen, Art, Design, Architecture and Applied Technologies Faculty, UNIACC, Valparaiso – Santiago de Chile, South America

The cybernetician Stafford Beer explain Viable System Model (VSM) basis in three elements: a triangle between decision and control, technology and environment. Each "organizational system", make "the action" from this three basic points. Beer worked at an interdisciplinary experience about technology, organizational communication on line, and interdisciplinary collaboration; inside de Chilean government innovation politics between 1971 and 1973. The project was named Cybersyn (Sinergic Cybernetic), or Synco Project. On this project Isaquino Benadof did a software named Cyberstride, the one who use a methodology similar Critical Path Method CPM. This methodology came from engineering prospective, and means to do a past time line, and then modeling "possible futures".

If we look at the "past futures", after the world second war, the Chilean architectural students change his study plans under the "avant garde" statements. They did a kind of "Viable System Model": the Integral Architecture. It means a designer study plan through three basic elements: human being + nature + shape. Two years process of "analysis", and then 3 years of "synthesis". The teamwork, the bio architecture study, and another similar statement, did South American post war architecture under the organic urban organizational concepts. And then, like a response, the new Chilean engineering, with Abraham Freifeld, talked about a neo organic constructivist: contemporary experiences about theory of relativity, "ki" oriental energy concepts, and gestalt therapy interactional models. It a second integral-organic viable system model from this prospective.

Parallel engineering experiences, with Carlos Martinoya group, did interdisciplinary models with cognitive visual perception, math, nuclear physic, and in the last sixties, with neurophysiology, theater, anthropology and sociology. Or the first Chilean electro acoustic music experiences with Vicente Asuar and Juan Amenabar, both engineering. In 1968, following the model "Integral Architecture" began the Art and Technology Faculty, in University of Chile, Valparaiso. Then, in the early seventies, when some engineering use the new prospective software, like Hellmuth Stuven, they invent "cybernetic" interdisciplinary and organic uses. Under HfG influence, Gui Bonsiepe like Technologic Institute of Corfo Chile, began to talk about Interfaz (interface), and the "value of use" of aesthetic with three steps: 1º Trouble-structure, 2º Design, 3º Work make. Then, ending the eighties Miguel Giacaman, did an anti virus, Vir- Det, with immunological bio model.

Developing a short history about interdisciplinary interfaces between "Viable Systems Models", and organic and integrated systems, may be made a final prospective about interfaces and future models, from South Pacific Cone experiences to another context.

The Cross-Disciplinary Challenges of Visualizing Data

http://wp.me/P2oVig-bF

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Abstract:

The amount of data currently available to industry and academia is immense, and has affected how we approach our work in many areas, from advertising agencies to pharmaceutical companies, from social to natural sciences. Called Big Data with a reason these huge data sets are powerful assets for gaining insight into all sorts of phenomena. With the omnipresent access to large amounts of data, mostly unstructured, computational techniques have become integral to data analysis.

However, given our cognitive constraints in understanding patterns from numerical data alone, new methods have been devised to explore and understand datasets, and ultimately communicate findings. Among those new methods, visual analytic tools have played a crucial role in the study of big data. Visualizations are ubiquitous and critically important to generating new knowledge in several fields today. The process of devising visualizations is not trivial; it can be time intensive requiring a methodical approaches from practitioners in many disciplines. What is needed is a 'common language' and shared skill sets that transcend conventional professional boundaries from computer science to graphic design. On one hand, the team needs to be able to interpret the underlying structure of a dataset in a very abstract, algorithmic way, as well as understand the process of mapping data attributes to specific visual encoding channels —skills that are natural extensions of basic computer science principles. On the other hand, practitioners need to be able to distill the tasks and define the best perspective into the data that once encoded as visual representations will capture the essence of the dataset —skills that relate to fundamental concepts found in design. Surrounding all of these skills is the need for practitioners to work in multidisciplinary environments and communicate with domain experts in order to extract knowledge about specific application areas — critical analysis, communication, and social skills are highly important.

In our personal experience, each of us had a subset of these required skills and had to learn the others so that we could have meaningful interactions with each other. Given the amazing opportunity that has opened up to all fields of knowledge provided by access to huge amounts of data, the crucial questions are: How do we gain insight? How do we define the appropriate methods to explore, analyze, and communicate information? How do we go about teaching the upcoming generation of visualization practitioners and data scientists all of these skills? We hope for more effective, structured and scalable way to do this, rather than the serendipitous trajectories that we went by. We see several major challenges ahead, from education of the future

generation to supporting mechanisms to those already working in this space. For example, can we define a common knowledge base and think differently about teaching computer science and design principles with the goal of visual analysis in mind? How to bring these common set of skills to the cross-disciplinary teams of current practitioners?

The White Paper will examine the current state of affairs and articulate the challenges posed by big data and the urgent need for tools to examine and generate new insights. Our goal is to devise a set of recommendations and establish best practices to explore and develop visualization solutions to Big Data.

Exploring a Model of Inter-Disciplinary Research Collaboration Based on Collective Action Theories

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Interdisciplinary action lacks a theoretical framework that serves as a basis to self-reflection and dialog. In fact, there is not even a clear definition of what can be considered interdisciplinary action.

The objective of this paper is to develop a theoretical model to analyse and facilitate interdisciplinary dialog and collaboration between art, science, engineering and humanities. The model is inspired in key concepts taken from sociological Theories of Collective Action, which, usually are applied to understand different kinds of collective actions (for instance they are used to understand the action of ecologist, feminist or pacifist movements, among others). We propose that these theories can be pertinent to understand, in a very structured way, the interaction between the main dimensions, agents, resources, contexts and strategies of interdisciplinary action after a little conceptual translation or adjustment.

The hypothesis is that interdisciplinary action can be understood as a form of collective action according to the following definition: Collective action is "the result of a social action (or collective challenge) carried out by the set of formal and informal interactions established between (1) a plurality of individuals, collectives and organized groups (who share, to a greater or lesser extent, a sense of belonging or collective identity among themselves) and (2) other social and political actors with which they come into conflict. This conflict is triggered by the appropriation (of), participation (in), and transformation of relations of power to achieve social goals, and above all, through the mobilization of certain sectors of society" (Tejerina, 2010).

When collective action forms groups it is crucial to understand how these collective entities are shaped by means of discussions, negotiation and re-negotiation processes and not take their existence for granted.

Given the different forms in which interdisciplinary collaboration or interdisciplinary entities have historically developed it is not possible to present any essential definition of this kind of action. In each age there has been a variety of ways, objectives, motivations and concerns to develop this kind of collaboration.

There is a need to develop a typology of different kinds of interdisciplinary collaboration in which the elements that structure it are reflected. However, although this typology is still to be

done, there are a few elements present in each of one the possible kinds and upon which interdisciplinary action depends. This paper will focus on the key elements to construct a theoretical model for interdisciplinary action. These elements are: (1) the components of collective action, that is to say, why, where, when and in which way collective action happens (Theory of Collective Behaviour, Smelser, 1963); (2) the relationship between costs and benefits of collective action, that is to say, the dependence of collective action on available resources, group organization and opportunities and on the strategic and political factors involved (Theory of Resource Mobilization, Jenkins, 1983; McCarthy and Zald, 1977); (3) context interaction (Theory of Social Interaction, Turner; Kilian, 1957); (4) the political aspects (Theory of Structure of Political Opportunity, Kriesi, 1992; Tarrow, 1989, 1994; 1998); (5) the collective sense and aims (Theory of Collective Identity, Melucci, 1995), as in collective actions there is a blend of intentions, resources and limits. Collective actions imply intentional decisions and interaction structures inside a system of opportunities and restrictions.

The concept of interaction structure is central to analyse how interdisciplinary research and creative work, learning and knowledge transmission processes develop (regarding agents, ways, tools and environments). Having the broad map of these structures will improve our capacity to suggest the best actions to different stakeholders, specially to those in the position of making decisions; to identity and overcome obstacles and to enhance opportunities for collaborative action across science, engineering, arts and design.

Opportunities and obstacles will be identified according to different spheres and scales: (1) in the scale of face-to-face interactions (such as linguistic opportunities and problems, cross-communications misunderstandings and insights, etc.); (2) in the scale of inter-disciplinary power synergies, struggles and competitions such as those that belong to authority and power elites inside each discipline (interest groups); (3) in the scale of institutional educational and research structures that are discipline-based and can be seen as structures for new opportunities or threatens to any kind of interdisciplinary action; (4) in the scale of the social paradigm that is common in public political-administrative systems of funding at different levels like national, regional, European or international that are not adapted to interdisciplinary action (for instance, it is considered appropriate that a scholar follows a unique lineal disciplinary path during her/his academic trajectory and any break in this lineal path needs to be justified so that the carrier is considered adequate to academy, what reflects a Cartesian mode of thinking about academia and constitutes an obstacle for interdisciplinary fluidity).

The paper will contribute to improve the vision on how interdisciplinary actions change knowledge production and how the aims, motivations, and interactions around interdisciplinary problems synchronize and find resonance (or not) in an environment of limited resources and changing opportunities in which there are collaborators and opponents that need to dialog. Each Suggested Action will be related to the big picture but addressed to each different stakeholder in its own sphere of action (for example: artists, designers, engineers, scientists, educators; funding agencies).

Important Principles Involved in Considering Race and Ethnicity in STEM Outreach Initiatives

http://wp.me/P2oVig-g9

Coordinators: Dr. Jerome Morris, University of Georgia, and Dr. Alan Shaw, Kennesaw State University

Addressing concerns related to race and ethnicity is one of the explicit goals of the Broadening Participation objectives in many of the NSF's initiatives. Those objectives involve making good faith outreach efforts to groups that are underrepresented in the STEM fields. Along with women and persons with disabilities, the underrepresented groups include African Americans, Hispanics, Native Americans, Alaska Natives, and Pacific Islanders. This list of racial and ethnic minorities should make it clear that good faith outreach efforts should consider basic questions about what makes the racial and ethnic identities within these groups unique, and what is relevant about the circumstantial and historical realities faced by these groups. There are critical social, cultural, and policy issues to explore in order to provide a lens for understanding the relationship between culture, schooling and learning, as well as to apply such thinking to any approach to remedy the problem of underrepresentation. In order to address these issues, any outreach effort needs to (1) consider the dynamic interplay between macro forces (geography, economics, politics, race and ethnic forces) and micro forces (groups' cultural patterns and beliefs) in influencing access to opportunities and the students' choice to participate in the opportunities; (2) consider how culture emanates from structural forces, that culture is learned, and that people change cultural patterns and acquire new ones; and (3) consider the various groups who directly influence the particular cultures and cultural identities involved (e.g., family, school, religious communities) and how these different groups might play integral roles in outreach efforts.

Traditional STEM considerations that ignore issues of culture and identity at the macro and micro level are simply inadequate to fully address the problem of underrepresentation among specific racial and ethnic minorities. However, where traditional approaches fail, broader approaches that incorporate the arts and design within STEM activities offer a clear way forward. Two previous NSF funded initiatives are both a case in point. One sought to combine Native American culture and art with explorations of computer and computational science (NSF Award #CNS-0540484), and another sought to teach fundamental STEM paradigms using visual arts modules featuring African American artwork (NSF Award #HRD-0625731). These projects brought issues of "cultural resonance" into STEM curricula, and yet along with their successes, the projects also revealed a need to incorporate more hands-on design-related activities into the students' experience. Incorporating cultural experiences along with the act of building something meaningful in a shared context touches on issues of identity in more ways than does just incorporating cultural content alone. The way forward involves moving from STEM to STEAM/SEAD initiatives that explicitly address issues of culture and identity and that involve the constructionist notion of building shared constructions. In this paper, we will provide a framework for how to examine and address these issues in practical ways, and we will offer Suggested Actions for implementation.

Complex Contemporary Art Organizations: New Transdisciplinary Models

http://wp.me/P2oVig-d7

Coordinator: Philip Nadasdy

Complexity offers new strategies for contemporary art organizations to support their missions. From the lens of arts administration, this White Paper draws on complexity theory as an organizational strategy for contemporary art organizations. Rather than developing peripheral or alternative models to existing institutions, a networked infrastructure of organizations of varying sizes and disciplines would yield innovative, transdisciplinary programming and facilitate otherwise difficult to obtain resources on an ad hoc basis.

The unstable and isolated nature of contemporary art organizations in the U.S. hinders the development of mutually beneficial and sustainable networks. Complexity, though, serves as a set of tools in which instability becomes an asset, leading to emergent forms of programming and dynamically responsive organizations. Comparable international examples like L'Internationale [http://internacionala.mg-lj.si/] and Museum as Hub [http://www.museumashub.org/about] act as stepping-stones, yet the absence of external disciplines within these networks leaves room for transdisciplinary innovation.

Drawing parallels between principles of complexity and relevant contemporary art and curatorial practices, the White Paper calls on contemporary art organizations and funders to imbue these links into their organizational models, and for increased development of programming structures specifically designed to network contemporary art organizations with external disciplines. Additionally, the White Paper identifies contemporary art organizations as potential public platforms for SEAD research and projects, expanding beyond higher education institutions.

Co-Operation Cuisine: SEAD Interactions in Foodscapes

Coordinator: Alok Nandi

The concept: cuisine and food design as terrain to investigate complex wicked problems.

Conversation. Emergence. Food for thought.

- Cuisine, is French for 'kitchen' and first meant that or 'a culinary establishment';
- Cuisine, culinary art or the practice or manner of preparing food or the food so prepared;
- Cuisine, kitchen available with varying levels of equipment.
- Food, material that contains or consists of essential body nutrients, and is ingested and
  assimilated by an organism to produce energy.

Hundreds of years ago, the Hindu scriptures Upanishad were already mentioning 'You are what you eat', and more closely in Europe, in 1826, Anthelme Brillat-Savarin wrote, in Physiologie du Goût, ou Méditations de Gastronomie Transcendante: 'Dis-moi ce que tu manges, je te dirai ce que tu es.' Tell me what you eat and I will tell you what you are.

If design allows 'transformation of existing conditions into preferred ones' (Herbert Simon), 'cuisine' is interesting to put next to it, close to it, into it, or vice-versa. Especially as a process but also as a space (and a non-space), it might ensure that thinking and talking about 'design as cuisine' or vice-versa results into reframing making and consuming. Why would Cuisine allow to enhance the design envelope, the design thinking, the design attitude?

From cuisine and design, if we enlarge the view points and look at these dynamics in a transdisciplinary SEAD mode, by inviting scientists, technologists and artists, what exchanges will happen ? Food for thought …

Quite recently, the concept of "co-creation" shows interest in different areas, from innovation studies to information management, from design thinking to policy definition. How is the food sector using it to foster innovative propositions?

Private corporations are opening up innovation modalities, especially in the R&D phases. A number of companies are also looking to tap into the creative input at the market level. In parallel, public institutions in Denmark, in Finland, … are exploring new collaboration models, empowering and engaging everyday people. Forrester recently claimed: "Co-creation will become a pillar of product innovation by 2015. Although the market remains relatively immature, we have witnessed growing awareness of co-creation from our clients across a wide range of industries, and we continue to see empowered product strategy professionals experimenting with co-creation engagements in interesting ways. Co-creation will continue its upward trajectory in 2012, driven by emboldened vendors that are eager to show product strategists the value and benefits that co-creation can bring to the product development process."

The food systems have applied different mechanisms, from field to fork, through-out centuries, in resonance with several co-creation approaches and paradigms. However, one might claim the food chains in the 20th century industrialization phases may have wiped out some multi-stakeholders co-creation innovative collaboration by building "Fordian" production chains. Consumers have consumed, under marketing pressures … And then appeared phenomenas such as Slow Food in the Western world !

This whitepaper aims to look at different readings of understanding the food systems, depending if it is an "academic" approach or a "designer" point of view, or an "industrial" implementations, or an "artistic" reading.

Ultimately, the knowledge expansion might emerge out of the SEAD friction. Which dimensions would be appearing? Which stakeholders? What levels of operational and co-operational would be possible?

Input welcome !

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Alok b. Nandi, born in Congo and raised in Zaïre, is based in Brussels, where he has studied engineering, management and film (Licence en Philosophie et Lettres). As a designer, media artist and writer-director, he explores conflicting constraints in evolving and hybrid contexts, via his design label Architempo, with a focus on interaction design, exhibition design and food design.

From hi-tech interactive installations (Extrafiction framework) to lo-tech mise-en-scene (i.e. Cannes Film Festival and Jules Verne exhibition design), he is dealing with storytelling in multiple media, place and technologies. Japan Foundation Fellow. He has worked as head of new media in publishing houses (Casterman Tintin, Flammarion). He is also a regular speaker in international conferences in Asia, Europe, US. Invited professor/lecturer. He has launched Pecha Kucha Brussels, Ignite and is local leader of IxDA (interaction design).

From co-design to co-creation, from immersive installations to food systems, from connected story spaces and films to radio chronicles, he is busy with a large palette of narrative modalities. In 2011-12, he has launched coCreationcamp and coCreation cuisine.

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Towards a Taxonomy of the Challenges Within Typologies of Collaborations Between Art – Design – Engineering – Science – Humanities – A Practical Guide

http://wp.me/P2oVig-9H

Coordinator: Jennifer Kanary Nikolov(a)

Advisory Group: Anna Dumitriu (UK), Lucas Evers (NL), Kaisu Koski (NL/fi), Megan May Daalder (USA), François-Joseph Lapointe (CA), Roger Malina (FR/USA), Frederik De Wilde (BE), Robert Zwijnenberg (NL) and hopefully more experts!

To join please contact Jennifer Kanary at jenniferkanary-AT-yahoo-DOT-com

Collaborations between Art – Design – Engineering – Science – Humanities, have a tendency to look great on paper, sound logical to the mind, but are far from easy to achieve in reality. In spite of good intentions and high motivation, many initiatives become tainted with disappointment. Why is this? Where do such collaborations tend to go wrong? What are the secrets to successful collaborations? What needs to be taken into account? Which aspects facilitate organization? By understanding the complexity of problematic issues that surround such collaborations we hope to begin to build an educational tool that may be used as a practical guide by those who aspire such collaborations.

With this SEAD White Paper we propose to develop an initial taxonomy of challenges involved with different typologies of collaborations between Art – Design – Engineering – Science – Humanities. In order to do this we will develop a questionnaire and put out a call to artists, scientists, engineers and designers, who we hope will share their expertise by elaborating on key aspects of failure and success within their experiences of collaborations. By mapping the challenges within different typologies of collaborations, collaborators may identify themselves into roles and responsibilities with a stronger awareness of achievable aims and results.

We invite all interested to join this working group to develop a SEAD White Paper on taxonomies the challenges within typologies of collaborations between Art – Design – Engineering – Science – Humanities; We realize that in rapidly emerging new areas of practice, terminologies and taxonomies also evolve rapidly; this in itself is a record of how the collaborations lead to new trans-disciplinary or inter-discplinary forms. We will in this White Paper identify Suggested Actions concerning the developing of useful taxonomies that clarify the variety of situations, obstacles and opportunities, to facilitate Science and Engineering to Arts/Design/Humanities collaboration.

We invite authors of existing taxonomies or classification systems to contact: jenniferkanary-AT-yahoo-DOT-com

What is an Interdisciplinary Research Team?

http://wp.me/P2oVig-gd

Coordinator: Sile O'Modhrain

For the past 20 years or so, both academia and industry have placed much emphasis on the importance of interdisciplinary research, research that draws upon a broad range of skills and interests in the service of a common goal. Whether through the mechanism of collaborative projects in the classroom, collaborative grants, or through the hiring and resourcing policies of industrial laboratories, such teams are now a mainstay of today's research landscape.

However, the assumption that simply bringing together a group of talented and skilled researchers who are enthusiastic about a given project is sufficient to deliver innovative research is somewhat naive and can often result in an experience which is disappointing for both the members of the team and the project's stakeholders.

Drawing on 20 years of experience of both working within and directing interdisciplinary research teams in the fields of haptic interaction and digital musical instrument design, the author suggests that, by giving some thought to the balance and distribution of skills and interests of team members at the point of recruitment, and by gaining a better understanding of the process of development that must take place within the team during the lifetime of a research project, the quality of the interdisciplinary research experience can be greatly improved both for individual team members and for the wider community of stakeholders in the project.

SARC (Scientists/Artists Research Collaborations)

http://wp.me/P2oVig-bb

Coordinators: Jack Ox and Richard Lowenberg

SARC seeks to understand and foster examples for how mutually furthering collaborations among artists and scientists can be encouraged, stewarded and realized, with ultimate social benefits, through collaborative processes, research, learning and creation of new works.

SARC intends to develop a pragmatic yet creative strategic path forward, document its research and projects, evaluate methodologies as case study scenarios, determine problems and issues of interest to all parties, work on projects that address questions and afford solutions, coordinate with regional education programs and foster valued benefits for local and global society. Ultimately, SARC will focus on creation of new works, in the convergent sciences and arts.

SARC's Summer 2012 pilot initiative laid the groundwork, creating a space where conversations and relationships were initiated between selected artists and interested science researchers, in order for them to continue collaborations in any combination that fits developing target issues. The first five artists chosen from a SARC- ISEA2012 international call, spent parts of Summer 2012 communicating and interacting with researchers at both Sandia and Los Alamos National Laboratories (LANL). A two-day Working Group meeting in September at Santa Fe Institute, included intensive scrutiny of the SARC pilot experience while also focusing on larger issues and opportunities facing ongoing art-science collaboration.

University of New Mexico is also directly involved through the Center for Advanced Research Computing (CARC). Start-up funding for SARC's Summer 2012 initiative was provided by The New Mexico Consortium, at LANL, and by Lockheed Martin-Sandia Labs. Under fiscal sponsorship of 516 ARTS in Albuquerque, SARC's Summer collaboration processes and outcomes were showcased at ISEA2012 through a series of regional community panel discussions, presentations and an exhibition.

Art-Science is a hybrid. When successful, it blends aspects from both the domains of the arts and the sciences, and remains open-mindedly ventilated to benefit from many disciplines and worldviews. Traditionally, there are oppositional values, including a graduated linking scale between them, which shows conceptual connections between both domains in varying degrees. Some of these oppositional values are: explanatory versus experiential; quantitative versus qualitative; or simply having the goal of only one possible outcome on the science side — to acceptance and possible joy for having multiple possible outcomes from a single hypothesis on the art side.

There are also many organizational, structural and economic variations for SEAD initiatives, including those initiated in universities, by corporations, by funding institutions and federal agencies, by nonprofit entities and by individuals. Most attempts to engage artists and

designers and engineers or scientists in projects to date have produced un-equal collaborations; with the artist serving as a graphic illustrator for science researchers, or engineers/technicians creating the apparatus or applications needed by an artist to do their work. This has proven to not be sustainable. The advent of digital code and media technologies has largely taken precedent over broader issues that are the domain of the sciences, resulting in creative works of 'techne' rather than of 'world-views' and complex understandings. Art-Science ought to seek a more balanced approach, achieved by nourishing and developing all sides of the equation.

Some of the evaluation questions to be considered by SARC participants:
• Is there a successful methodology for enabling equal but diverse collaborative relationships? What are other assessed 'best practices'?
• A conceptual blend results in emergence: a quality that is more than the sum of its parts. Are there aspects of the collaborations that have 'emergent' qualities?
• If mutual arts and sciences benefits are realizable, how may they be valued, as basis for development of emergent and supporting program economic models?

While we understand that the very term and individual words 'art and science' are self-limiting, we also understand that there are many variations on the Art-Science theme, and that SARC is only one among many rich possibilities of contextual variations. SARC will be a unique case study, not directly replicable or applicable to all other SEAD initiatives, but a most important opportunity to learn, practice and apply necessary lessons that may inform timely and vital actualizations of trans-disciplinary socially motivated objectives.

Interaction Design and Liberal Arts Education

http://wp.me/P2oVig-bZ

Coordinator: Oguzhan Ozcan

As known, the discipline of Interaction Design feeds on many other disciplines, prominently social sciences, engineering and art. This multidisciplinary subject is taught at times as part of engineering curricula and at times with art and design. It is, however, debatable; whether this subject, which does not wholly belong to a particular area of study, may be taught as a complete professional degree in this manner. Consequently, the structure of a liberal arts education may pose an alternative to the way that Interaction Design is taught. Thereby, this White Paper will seek to answer the following questions: How can Interaction Design be taught as part of a liberal arts education and what kind of an education structure may be utilized?

The Coming of Age of a PhD Program in Digital and Experimental Arts Practice: Lessons Learned and Challenges for the Future

http://wp.me/P2oVig-h0

Coordinators: Juan Pampin, James Coupe, Center for Digital Arts and Experimental Media (DXARTS), University of Washington

The Center for Digital Art and Experimental Media (DXARTS) is based at the University of Washington in Seattle, USA. Over the last five years, it has established itself as one of the leading research centers for digital art in the USA. No commercially-sponsored research is undertaken, and DXARTS' highly selective PhD program offers full tuition waivers and stipends to its students. Students are expected to develop original research specializations based on their art practices, and receive support and resources to establish long-term legacies for the program. Unusually for a digital arts program, DXARTS has invested heavily in non-screen based studio facilities, including a 5000 square foot warehouse that incorporates state of the art CNC fabrication, electronics laboratories, exhibition space, as well as more traditional wood and metal workshops. DXARTS actively pursues interdisciplinary collaborations across the University, including affiliations with Music, Dance, Computer Science, Engineering, Physics and Biology. Visiting scholars include scientists as well as artists, and the program includes post-doctoral researchers with PhDs in Computer Science and Engineering and other STEM fields.

As such, DXARTS is positioning itself to fully explore the notion of artistic experimentation in the 21st Century. This experimentation is a cross-disciplinary endeavor that requires a new generation of artists, with expertise in computing and the sciences who have followed a research and teaching agenda equivalent to those found in other fields (rather than the traditionally terminal degree in the visual arts, the MFA). New and unusual research strands have emerged as a result, resulting in publications and patents that make broad contributions across multiple disciplines.

DXARTS can therefore be considered as a new kind of research center, asserting the value of artistic knowledge and problem-solving and claiming it as equivalent to that in other fields, and of vital importance. Nevertheless, funding models for DXARTS are to be found in the arts rather than in the sciences, resulting in a lack of substantial, long term resources to pursue its research trajectories. In the arts, with a lack of national arts funding organizations, this means commissions, competitions, and local art grants. Access to NSF-style funding is problematic due to a lack of recognition of the value of creative research, and a lack of access to program managers in funding agencies. Whereas a scientist would develop necessary funding relationships via their PhD and postdoctoral advisors, a PhD student in creative technology fields has no conventional route to acquire funding appropriate to their research.

This paper will outline research areas emerging from DXARTS that demonstrate cross-disciplinary outcomes, and include detailed proposals for funding interdisciplinary creative research.

The Openlab Network Facilitates Innovative, Creative and Collaborative Research with Art, Community, Design, Technology, and Science at the University of California, Santa Cruz

Coordinator: Jennifer Parker, Associate Professor and Chair of the Art Department, co-founded and is Executive Director of the OpenLab Network, as well as Affiliate Faculty of Digital Arts & New Media

Obstacle1: Jennifer Parker, an art professor at the University of California, Santa Cruz, was trying to help Enrico Ramirez-Ruiz, an astrophysics professor, assist a student on an interdisciplinary project when she realized that neither professor had permission to use the other department's studios, labs, or facilities. Obstacle 2: Amy Bower, an art history student, and Jack O'Neill, a business student, each with interests in sustainability, had an idea for a convertible sleeping pad that could be used by artists, scientists in the field, for low-income residents of developing countries, and even for survivors of natural disasters. But neither had a place to make their prototype or equipment to test their design.

The solution to these obstacles was creation of the OpenLab Network, which Parker and Ramirez-Ruiz co-founded in 2010. At its first Summer Institute in 2011, faculty and graduate students across disciplines shared space, expertise, creative ideas, and differing modes of discovery on projects with multiple outcomes. Parker describes the Institute as working like a movie crew with each team member bringing their particular expertise to a task that will produce a joint outcome. Scientists propose a concept, and work with artists with backgrounds such as photography, digital art, filmmaking, and sculpture, in four- to seven-member teams. OpenLab's first projects debuted at an exposition at the Tech Museum of San Jose, CA, where visitors could learn about hard-to-understand concepts through these science/art projects – for instance, playing a game where they step off Earth and hurl a star into the cosmos to learn about black holes. Sudhu Terwari, a graduate student in music and art, was part of a team that developed a three-dimensional zoetrope to make visual the collision between the moon and a sister moon that orbited Earth. Working with the interplay across disciplines, artists were challenged to take real-world problems and develop solutions that would engage viewers and participants, while science faculty and students learned how to ask and answer questions that had never occurred to them where the problem existed only on paper or in the lab.

The work has the additional advantage of involving in STEM students from underrepresented backgrounds, for whom the unthreatening, "playful" atmosphere of the interdisciplinary collaborations provides both an entrée to science and scientific questioning, and a sense of the range of applications of STEM fields.

Compared to the expense of many scientific undertakings, this new perspective is also replicable across other institutions and internationally, and cost-effective. The inaugural year of the Summer Institute was supported by existing facilities (with broadened access), with some contribution from NSF, NASA, the Packard Foundation, the UCSC Arts Division, and the UCSC Foundation. National and international funding bodies can foster these cross-discipline

"transfusions," as Parker calls the benefit researchers receive, by encouraging STEAM projects and tailoring application timelines and requirements to fit. The ultimate benefit is not only to students, and to the public efforts to understand science, but to science itself. Working with artists has opened new dimensions, says Ramirez-Ruiz, changing the way he thinks, and changing the way he visualizes scientific phenomena, how we arrive at "discovery," and the world itself.

Fragments /Examples on Science / Art / Collaborations and the Local / Social / Personal Context

http://wp.me/P2oVig-ci

Coordinator: Miklós Peternák

1. *"Ich habe ein eigentümliches Tier, halb Kätzchen, halb Lamm." (I have here a strange animal, half cat, half lamb.)* – wrote Franz Kafka in his short story entitled *Eine Kreuzung*. This reflects a tone that is typical of the 20th century, one that we may apply here in order to meditate the diverse forms and especially perspectives of art /science cooperations

2. Once I tried to summarize some historical experiences of experimental art / science relationships as follows: Art upholds and strengthens the validity of personal knowledge of the unknown. This revelatory aspect of cognition is absent from everyday life. Science has confined itself to the gathering of information, its study and acceptance, and the comprehension of its results has—rightfully—excluded direct experience, or else presents it as an exception. Science has forfeited the condition of providing occasion for the sensory insight that constitutes *private knowledge*, beyond the academy—whereas art has proved capable of taking on that role, even as it adopts scientific terms and systematic concepts. (*Miklós Peternák: Art, Research, Experiment: Scientific Methods and Systematic Concepts. = Beyond Geometry: Experiments in Form, 1940s-70s. Los Angeles County Museum of Art – The MIT Press, Cambridge, Massachusetts and London, England, 2004, pp. 89-111.)*

3. During the last twenty years I was involved in the formation of two new initiative in Hungary, the Intermedia Dept. at the Hungarian University of Fine Arts (from 1990) and the C3: Center for Culture and Communication *http://www.c3.hu* (from 1996). These two institutions are different in social context as the University belongs to the state while C3 between 1996 and 1999 was az experimental pilot project financed by the Hungarian Soros Foundation than from 1999 till now exised as a non-profit foundation, an NGO. However the initial mission of both were close to each other.

Since its foundation C³ has focused its energies on fostering the integration of new technologies in the social and cultural tradition. The main objectives are production, presentation, dissemination and preservation of electronic arts and culture (interactive installations, experimental multimedia, net-art) including the collection, archive, documentation of contemporary (media) art as well as the artistic applications of the new technologies. C3 organized several public events in the context of art / science collaborations like:

The Butterfly Effect project *http://www.c3.hu/scca/butterfly/headers.html*
Scientific Application of the Image symposium
http://www.c3.hu/events/99/mintakep/index.html the
Perspective http://www.c3.hu/perspektiva/encartframeen.html and
Vision http://vision.c3.hu/en/home.html exhibitions, conferences etc.

The Intermedia Department had developed simultaneously with similar European undertakings while relying heavily on local circumstances. At the time of the program's commencement in 1990, the overwhelming local circumstance in Hungary (and in all of Central and Eastern Europe) was the unprecedented process of reprogramming and reshaping a bankrupt political and economic system into a working society. The emergence of new media technologies in all walks of life brought about a fundamental change in the area of cultural/artistic work as well. Therefore the primary objective of the training was to enable students to realize the potential of their individual personalities so that they may develop an active and creative presence in the cultural spheres of the information society.

4. As for art, it is crucial to mention that during these 20 years in the middle of Europe it was the political and economic systems of the region that changed, but not the predominant tastes. In other words, the new landscape is more favorable to innovative, contemporary, and bold currents in art only to the extent that the threat of outright banning no longer means that survival in the field is impossible.

What I can try here is to describe this story and in this way provide informations to someone who can judge from a more pragmatic aspect as if it was a success or failure. Such an overview about lessons learned together with possible recommendations can be useful especially due the need of the continious search of next steps / future tactics.

Fueling the Innovation Economy: Increasing K-12 Student STEM Engagement, Learning, and Career Interest through Integrating Mandated Content with the Arts and Creative Thinking Skills

http://wp.me/P2oVig-nZ

Coordinator: Lucinda Presley, Executive Director, ICEE Success Foundation, an arts/science/creativity institute, (ICEE: Institute where Creativity Empowers Education Success), USA

Advisor: Linda Scott, Ph.D., Executive Director, School Science and Technology, Weiss School of Natural Sciences, Rice University, US

Working Group Members:
Rob Gorbet, Professor of Engineering and Knowledge Integration, University of Waterloo, and engineer for the Philip Beesley Hylozoic Ground project, Canada
Rick Hall, Director of Programmes, Ignite!, an arts/science/creativity initiative, UK

Additional proposed members:
Mike Petrich, Director, Making Collaborative, Exploratorium, USA
David Delgado, Outreach Coordinator, Mars Public Engagement Team, Jet Propulsion Lab, USA
Alex Hesse, Director, The Leonardo arts/science/technology Museum, USA Carol LaFayette, Associate Professor, Department of Visualization, Texas A&M University, USA
Mary Hobbs, Ph.D., Coordinator for Science Initiatives, Texas Regional Collaboratives for Excellence in Science and Mathematics, University of Texas at Austin, USA
Elda Christian, Science Specialist, Texas Education Agency Region 1 Education Service Center, USA
Linda Scott, Ph.D., Rice University, USA
Dara Williams-Rossi, Ph.D., Director of Undergraduate Programs and Assistant Clinical Professor, Annette Caldwell Simmons School of Education and Human Development, Southern Methodist University, USA

According to a number of nationally-recognized researchers, authors, educators, businesses, governmental panels, and studies, the United States' future place in the global economy could be significantly impacted by the degree to which today's students are taught to think innovatively (Friedman, 2011, 2009; Florida, 2003; Robinson, 2011; Zhao, 2009; President's Councils of Advisors on Science and Technology, 2010; National Science Board, 2010; Gardner, 2008; Bransford, 2000; MIT, 2003; Edwards, 2008). They point out that, in order to be competitive in this rapidly-changing world, our students must learn to integrate vital 21st century innovation thinking skills with science, technology, engineering, and math (STEM) learning skills. The thinking skills include: conceptual and visual thinking, creative/critical thinking, collaboration, and communication. The integration of these skills with science, technology, engineering, and math concepts promotes students' abilities to problem-solve and design innovative solutions. (Starko, 2003; Cropley, 2003; HMIE, 2006; NAS, 2002; P21). In the current test-driven education environment, it is vital to develop ways to integrate these important thinking skills with the mandated, standards-based learning. While strides are being made by such groups as the

Partnership for 21st Century Skills (P1), and some state education agencies, there remains significant room for further examination of the education roadblocks and opportunities. While the test-driven culture provides roadblocks, it also provides opportunities to develop ways to deeply integrate the vital thinking skills with content delivery. Opportunities include: state, national, international collaborations among disciplines and forms of content delivery. These integrated disciplines include the fine arts, science, technology, engineering, language arts, and math. Forms of delivery can include the integration of formal and informal education methodologies. For this paper, we propose to discuss the roadblocks that the education world faces in promoting creative thinking, along with the opportunities that this situation presents. Additionally, we will present solutions that have been implemented and are being researched by the members of this group, along with specific calls for action. The calls for action will include the integration of state, national, and international resources to produce research-based proposals for education changes that can be presented to education stakeholders.

How SEAD Could Contribute to Experimental Economics in Action: A Case Study of Innovation and Entrepreneurship in Support of Rural Community Development

http://wp.me/P2oVig-bT

Coordinator: Joan Quintana and Jose Quintana, Advent GX Corp.

In seeking approaches to spur economic growth and job creation in America's rural regions, Advent GX identified gaps, studied best practices and evaluated tools for their potential application to rural settings. By providing access to relevant tools and using approaches that foster innovation and spur entrepreneurship and small business enterprise, all the while benefiting the community, the Advent GX approach removes barriers and sets communities on a path to prosperity.

Relevance of tools is fundamental. Too often well-meaning rural leaders attempt to employ methods that have proven effective in urban settings. Vastly different local dynamics, engagement and funding levels mean many conventional tools are out of reach and inapplicable. By modifying proven systems to the rural situation, facilitating creative collaborations, and allowing both local vision and market dynamics to drive strategy formation and implementation, Advent GX is moving beyond traditional rural development strategies and realizing success in assisting rural communities through the growth process.

Cultural and Heritage Assets: Natural Attractants for Tourism and Innovation

Tourism development often is considered to have the best potential for attracting outside investment and generating sales tax revenue in rural communities. Experiential tourism–including heritage, cultural, nature tourism, to name a few–does in fact present a significant opportunity for rural places to expand the economic base and enhance quality of life. But tourism is just a beginning.

The natural attractants that bring visitors to local downtowns also serve to improve the quality of life. Establishing unique shopping experiences, live music venues, quality dining and the arts in a defined downtown district provides a venue for intellectual cultural engagement. The small setting and relatively low population creates a sense of community. Soon the creative class of artists and performers are mingling with engineers, lawyers and other professionals seeking respite after a long day of work.

This experiential lifestyle—typically only available in urban settings—is a key attractant for innovators and entrepreneurs seeking the rural quality of life. Advent GX established the Innovation Underground, a privately owned and operated business incubator, in the heart of the cultural community of Historic Downtown Bryan to leverage the natural tourism attractants and provide a catalyst for entrepreneurial initiatives.

Community-Based Entrepreneurship: Behavioral Economics, Market Analysis and Financial Engineering for Start-Ups

Location within the heart of the community is essential. So too is a deliberate focus on serving the needs of both entrepreneurs seeking to start a business and freelancers in search of a quiet place to work. Serving both populations creates an ecosystem whereby freelancers feed off start-ups' need for affordable services. Start-ups have access to affordable services, low rent, shared meeting facilities and, importantly, Advent GX's version of entrepreneurial support systems. Unlike traditional business incubators and small business innovation centers, Advent GX advocates for a more aggressive and experimental brand of start-up.

Where the traditional approach calls for would be entrepreneurs to spend $50 thousand dollars for fundraising, prototyping and business planning, Advent GX employs experimental economics. Entrepreneurs will spend roughly half the cost of a traditional business plan to create a pilot product/program, do business development and fund raising – in that order. Unlike traditional incubation strategies that result in a business plan and perhaps some interested investors, Advent GX's reverse incubation approach yields a customer and initial product offering.

Advent GX works with incubated companies to capture the voice of the customer in order to define the functionality of products and services. Using a modified quality functional deployment process, and identifying opportunistic partnerships enables businesses to anticipate and meet customer needs and connect to a wider network of resources faster than the typical business planning processes. Cost effective market analysis tools and financial modeling provide valuable insight into best markets and revenue streams.

Opportunity for Replication and Suggested Actions

The Advent GX approach to community and economic development via heritage preservation, arts, tourism, and a strong entrepreneurial culture is working in Bryan, TX. Prior to official opening, the Innovation Underground is out of space for additional entrepreneurial start ups and has expanded to offer additional office space and virtual start-up assistance. The company's flat organization, focus on providing support as needed (avoiding one-size-fits-all services), and leaderships' inherent understanding of the entrepreneurial condition makes the operation viable from a practical perspective.

There is significant opportunity to extend the Innovation Underground to other communities and generate entrepreneurial activity in more rural places. While no two communities are alike, Advent GX systems for assessing local markets and potential ensure that entrepreneurial centers like the Innovation Underground are developed to fit with local culture. Business development tools can then be applied as needed to encourage entrepreneurship and development of vibrant rural communities.

The SEAD Network can play a significant role in enhancing the Innovation Underground experience for both entrepreneurs and communities. Likewise, the Innovation Underground can

provide SEAD with a living laboratory, free from discipline-specific turfs and academic bureaucracy that can be barriers to interdisciplinary engagement.

The whitepaper will provide insight into the Advent GX approach and explore solutions to the following questions:

1. How can governments provide financial support for the Innovation Underground without burdening the program with bureaucracy, thus compromising the agility required to meet the needs of private enterprise?
2. How can the Innovation Underground best serve as a venue for the implementation of SEAD Network initiatives, creating value at the community level while advancing academic research and education?
3. What incentives are needed to promote faculty participation in the Innovation Underground at the pilot location in Bryan, TX and in future locations throughout Texas and the US?
4. What research opportunities exist to document Innovation Underground methods and perpetuate best practices for the benefit of entrepreneurship, business incubation and economic development in general?

The Importance of Early and Persistent Arts and Crafts Education for Future Scientists and Engineers

Coordinator: Robert Root-Bernstein, Ph.D., Professor of Physiology

Rex LaMore, Ph.D., Director Center for Community and Economic Development
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K-12 curricula at in most school systems focus on mathematical and verbal skills, but the ability to succeed in science and engineering requires a broader range of skills that include observation, visualization, dimensional thinking, modeling, manual dexterity, familiarity with tools, transforming data into visual or graphical forms, converting theories into mechanical procedures, and even understanding data and experiments kinesthetically (Wilson, 1972; Ferguson, 1977; Ferguson, 1992; Root-Bernstein and Root-Bernstein, 1999; Root-Bernstein and Root-Bernstein, 2005; Root-Bernstein, et al. 2008;). All of these skills can be learned through arts and crafts experiences (e.g., Hindle, 1981; Ferguson, 1992; Deno, 1995; Sorby and Bartmanns, 1996; Alias, et al., 2002; Root-Bernstein and Root-Bernstein, 2005; Root-Bernstein, et al., 2008; Sorby, 2009;). As a result, we have found through a series of studies of scientists and engineers that significant arts and crafts experience is highly correlated with success in science and engineering as measured by outcomes such as major prizes and honors, patents, or the founding of new high tech companies (Root-Bernstein, et al., 1995; Root-Bernstein and Root-Bernstein, 2004; Root-Bernstein, et al., 2008; Lamore, et al., 2010; Root-Bernstein, et al., in press). One of the most notable results of our ongoing studies is that no particular art or craft confers any particular advantage over any other: dance, music, drama, painting, sculpting, printmaking, photography, making and composing music, metal- and woodwork are all correlated with increased probability of success. The operant factor is not the type of art or craft, but early introduction to arts and crafts in elementary and middle school years followed by persistent practice of that art or craft into adulthood. We also found that while exposure to arts and crafts can occur in a school setting, formal education is not a requirement for the observed correlation to success: arts and crafts classes in school were often supplemented or replaced by private lessons, informal mentoring at home or in community centers, or even by self-teaching. Again, the key element was not how an art or craft was learned, but the persistence with which it was pursued.

Given that most states within the United States, and most countries around the world, marginalize arts and crafts education to the extent that many students get no more than an hour of such education per week, and most are not introduced to more than one or two arts or crafts during their entire schooling, our findings have clear policy implications for a wide range of parties (Lamore, et al., 2010). Students interested in pursuing a science or engineering career must recognized that their formal K-12 schooling is unlikely to prepare them adequately in the

range of skills they will need to reach the top of their field: they and their parents will need to supplement the standard K-12 curriculum. Educators and those setting educational policy must recognize that there is a robust literature linking success in science and engineering to skills such as observing, visualization, and modeling that are developed by arts and crafts training: arts and crafts are not, therefore dispensable frills that can be eliminated from curricula whenever budgets need to be cut, but essential elements of science and engineering education. Finally, legislators need to understand the practical value that lies in the skills taught through arts and crafts so that they are willing to provide robust funding not only for formal K-12 arts and crafts curricula, but also for community centers, after-school programs associated with arts and crafts centers, museum- and concert hall-based educational programs, and other forms of informal arts and crafts education. The fact is that Innovators in science and engineering are artists and craftsmen as well, and there are practical reasons that this is so. Only when we understand the many ways in which arts and crafts make possible innovation in sciences and engineering will we be able to develop the full potential of our students.

References

Alias M, Black TR, Grey DE. Effect of instructions on spatial visualization ability in civil engineering students. *Inter Ed J* 3(1): 1-12, 2002.

Deno JA. The relationship of previous experiences to spatial visualisation ability.*Engineering Design Graphics J,* Autumn*,* 5-17, 1995.

Ferguson ES. "The mind's eye: Nonverbal thought in technology." Science 197: 827-836, 1977.

Ferguson, E. Engineering and the Mind's Eye. Cambridge, Mass.: MIT Press, 1992.

Hindle, B. Emulation and Invention. NY: New York University Press, 1981.

Lamore R, Root-Bernstein RS, Lawton J, Schweitzer J, Root-Bernstein MM, Roraback E, Peruski A, Van Dyke M, Fernandez L. "ArtSmarts and Innovators in Science, Technology, Engineering and Mathematics (STEM)" White Paper, Center for Community Economic Development, Michigan State University, 2010 http://www.ced.msu.edu/techresearchreports2010.html

Root-Bernstein, R. S., Bernstein, M. and Garnier, H. W. "Correlations between Avocations, Scientific Style, and Professional Impact of Thirty-Eight Scientists of the Eiduson Study," Creativity Research Journal 8: 115-137, 1995.

Root-Bernstein, R. S. and Root-Bernstein, M. M. Sparks of Genius, (Boston: Houghton Mifflin, 1999) [Book-of-the-Month Club Selection; Quality Paperbacks; translated into Swedish, Japanese, Chinese (two editions]. Paperback, Mariner Press, 2001; Centelhas de Genios, Sao Paolo, Brazil, 2001; Spanish: El secreto de la creatividad.Barcelona: Kairos, 2002; Korean: Seoul: Eco's Books, 2007.]

Root-Bernstein, R. S. and Root-Bernstein, M. M. "Artistic Scientists and Scientific Artists: The Link between Polymathy and Creativity" in Sternberg, Robert, Grigorenko, Elana L., and Singer, Jerome, L., editors, Creativity: From Potential to Realization(Washington, D. C.: American Psychological Association, 2004), pp. 127-151.

Root-Bernstein, M. M. and Root-Bernstein, R. S. "Body Thinking Beyond Dance: A Tools for Thinking Approach," In Overby, Lynette, and Lepczyk, Billie, eds. Dance: Current Selected Research, vol. 5, pp. 173-202, 2005.

Root-Bernstein RS, Lindsay Allen, Leighanna Beach, Ragini Bhadula, Justin Fast, Chelsea Hosey, Benjamin Kremkow, Jacqueline Lapp, Kaitlin Lonc, Kendell Pawelec, Abigail Podufaly, Caitlin Russ, Laurie Tennant, Eric Vrtis and Stacey Weinlander. "Arts Foster Success: Comparison of Nobel Prizewinners, Royal Society, National Academy, and Sigma Xi Members." J Psychol Sci Tech 2008; 1(2):51-63.

Root-Bernstein RS, Lamore R, Lawton J, Schweitzer J, Root-Bernstein MM, Roraback E, Peruski A, Van Dyke M. "Arts, Crafts and STEM Innovation: A Network Approach to Understanding the Creative Knowledge Economy" The Arts, New Growth Theory and Economic Development (Washington DC: National Endowment for the Arts and the Brookings Institution) in press.

Sorby SA, Baartmans BG. A course for the development of 3D spatial visualization skills. *Engin Design Graphics J* 60(1), 13-20, 1996.

Sorby S. Developing spatial cognitive skills among middle school students. *Cogn Process* 10 (Suppl 2):S312–S315. 2009. DOI 10.1007/s10339-009-0310-y

Wilson M. Passion to Know. Garden City NY: Doubleday, 1972, pp. 11-12.

Case Study: Cultivating Art and Science in the Petri Dish:
The Culture at Work Project

Coordinator: Sherryl Ryan

Culture at Work, in Sydney, Australia, is the most recent project that I have created as an artist – this project is different to its predecessors, it is not aligned with a university or museum or other institutions (yet). Culture at Work is based on evolutionary principles of growth through adaption and includes learning as a principle for all stakeholders.

Opportunities for engagement and connection between artists and scientists at Culture at Work continue to grow and relationships have been developing over the three year life of the not for profit. Research output includes multiple formats; art science exhibitions, artist scientist talks, video, art science workshops for young people, community engagement, blog sites.

Culture at Work has been able to make connections with key people across a range of disciplines at universities, research institutes, local councils and Government agencies, in particular its model of creative initiative and maneuverability. The model fits a need for creative thinking and innovative solutions for creative industries.

The project has been challenging due to lack of funding, it currently resides outside individual funding silos and priorities and does not fit into a single art or science or education category. Its innovation attracts a great deal of interest, from business, academics and science institutes however grant funding bodies' applications are restrictive due to format, existing categories and time frames; the research growing at Culture at Work is outside existing formulas and may be more relevant to the 'start up' approach. The creative process and art science collaborations follow incremental adaption rather than written substantiation of outcomes written in advance. Currently to ensure the integrity of the creative innovation it is easier to continue to work without funding to achieve flexibility and true innovation.

Obstacles that impede the speed of growth, development and communication of Culture at Work's activities include lack of funding; lack of resources to promote to the public the innovative projects that have been incubated and developed between artists and scientists. Exhibitions run for several weeks and only traces remain through photos on blog-sites, limiting the dissemination of the collaborative processes.

Recommendations include Governments setting aside funding that is not time-based that includes opportunities for artist-led organisations and models that incubate creative processes and evolutionary collaborations. Addressing this gap will ensure that new contributors can add to the bigger picture. Being outside the system can often give a new and valuable perspective to innovation and to the nexus or new space of art and science. Emptiness and new incubators are required for creative and new thinking – the new frontier requires new paradigms.
http://www.cultureatwork.com.au

Biography

Sherryl Ryan – Artist, Founder & CEO of Culture at Work an Artist-led Art Science Research Institute in Sydney, Australia. Formerly Gifted Education Coordinator at the Art Gallery of New South Wales 2003-2010 creating a new model for museum education for gifted children including 'The Da Vinci Project' connecting art and science in museum contexts with pre and post visit learning. Currently an Australian Higher Degree Research Student at the University of Sydney researching "the creative processes of artists and scientists and their environments."

Humanities Education in Karnataka

http://wp.me/P2oVig-7G

Coordinator: Sundar Sarukkai

Everybody seems to recognize that there is a crisis in humanities education around the world. As part of a report which I wrote for the Karnataka Knowledge Commission, I looked at the state of humanities education in the state of Karnataka, which, incidentally, is known as the science and IT capital of India. These are students who primarily enroll for the BA program across the state. The data from Karnataka actually reflect a larger trend across India – that a large number of students in the undergraduate actually take BA and related 'arts' programs. The figures could be anywhere from 40 to 50% of the total enrolment of undergraduates. Thus, in India, the problem is not that students are not taking up liberal arts and humanities, but the quality of these programs which range from the abysmal to mediocre with few exceptions. This note discusses ways by which we could address this problem in the State of Karnataka but might have some lessons for some others too.

Humanities in Science and Technology Institutes (A Case Study of One Institute in India)

http://wp.me/P2oVig-7F

Coordinator: Sundar Sarukkai

Abstract: In India, bifurcation between teaching and research has led to the creation of universities, which focused on teaching, and research institutes, which focused on research. This bifurcation, among other reasons, also led to the gradual deterioration of quality teaching and research in universities. A few years back the government started a series of science institutes (Indian Institute of Science Education and Research – IISER) which offer undergraduate and postgraduate programs in teaching but which also promote research like in the research institutes. In these institutes and the earlier ones in science and engineering (Indian Institute of Technology – IIT), there are humanities departments. However, these departments have often been viewed as second-class departments which were primarily there to offer 'service' courses to the science and engineering students. In this note, I discuss a particular case illustrating the challenge of integration between science and humanities departments in one of these IISERs.

Alternative Education through Community Practices as a Tool for Interdisciplinary Collaboration Initiatives

http://wp.me/P2oVig-f0

Coordinator: Andreas Siagian of Lifepatch - citizen initiative in art, science and technology
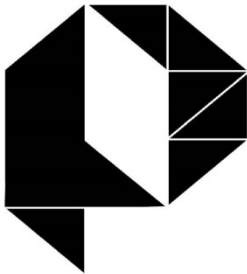
Local creative communities activities are growing rapidly in Indonesia especially in Yogyakarta, a city located in central Java which is known as the center of education, arts and culture of Indonesia. With more than 102 institutions of higher education, affordable living cost and its' strategic geographic position, Yogyakarta is one of the top destination city for students from all over Indonesia in pursue of higher education. By these backgrounds, Yogyakarta currently have remarkable creative communities consist of young people from various ethnicities and cultures. New communities emerged with activities in various fields, ranging from the focus on arts, science, technology, education etc., several often leads to inter-community connections between one another. From the development of various communities, many new initiatives were built by such interactions, the effort to collaborate with other creative communities to achieve a wider and complex goal through one collaborative actions. This is the main background of Lifepatch establishment in Yogyakarta, Indonesia.

Lifepatch itself is an independent community-base organization that works in a creative and effective applications in the fields of art, science and technology. It is run by youth with various disciplinary professions from the art and science fields. Lifepatch's mission is to aid the development of local human and natural resources by acting as a bridge for domestic and international collaboration platform which give open access for anyone to the sources of the research and development. Concerned to the needs of cross-collaborative actions between creative communities, Lifepatch conducted several activities which mainly focussed on alternative educative practices. One of the main activities is to conducts series of workshops to attract personals from different communities in interdisciplinary practices. These activities are the result of developing appropriate creative and innovative technologies such as biotechnology, digital technology with the spirit of DIY and DIWO culture. The flexibility of community working methods enrich innovative ideas and creations through interdisciplinary collaborations while alternative education practices enlarge network scope to reach interests from local creative communities.

One of the example of Lifepatch collaboration with local creative communities is Jogja River Project (JRP), an ongoing community project which started in April 2011. The project initiative began from Lifepatch collaboration with a community of scientist from the microbiology laboratory of agriculture faculty UGM Yogyakarta to measure water condition from Code River, the main river of Yogyakarta. Water samples were used to analyze Coliform bacterial pollution which have increased significantly due to the rapid development of riverbank settlements in urban areas. The project was then expanded with the collaboration with Cantigi community to create a visual documentation of the River. In 2012, JRP were conducted in 2 other river of Yogyakarta, Winanga River and Gajahwong River and was able to gathered participation from other people and communities which Lifepatch met during organizing workshops and presentations in the previous year. The result was an expanded range of activities from the main focus such as cleaning the river basin area from non-organic waste, mapping of natural resources, listing inventory vegetation and animals in the watershed and independent water resource empowerment mapping. While the project have drawn scientific and visual data which stated the danger of Coliform bacterial level, it is still in need of a contribution from designers and engineers to give an appropriate solution such as creating a safe and affordable water purification and sanitation for the local citizen in the local area. These thought of expanding the collaboration is the main challenge faced by Lifepatch. With the lack of support from local government institutions, Lifepatch needed to seek local and international collaborators in order to solve local problems.

Responding to technology development and practical use in daily life, Lifepatch see community-driven researches and practices in Indonesia as a huge potential waiting to explore. Inadequate infrastructure and conditions in Indonesia especially in terms of technological usage and community working methods has created innovative responds from the society. Sustainable actions were done to systematically expand or convert accessible technology to be used as multifunctional and cross-functional tools. These potentials however needed are essentially sporadic practices in which needed an organization which focused on interdisciplinary practices. These organization could help to create the structures needed to harness the community-driven practices and researche by involving artists, engineers, scientists and designers thus allowing these potentials to be evolved to a later stages. Currently there are very few organizations focusing in these issues in Indonesia which make Lifepatch consistency in their activities essential for their growth.

URL JRP: (indonesian) http://lifepatch.org/JRP_-_Jogja_River_Project | (English google translated): http://bit.ly/PnGkCO

Lifepatch – citizen initiative in art, science and technology | http://lifepatch.org | http://twitter.com/lifepatch | http://facebook.com/lifepatch

Cultivating Artscience Collaborations that Generate Innovations for Improving the State of the World

http://wp.me/P2oVig-8w

Coordinator: Todd Siler

There's an art to catalyzing collaborations and a science to developing innovations that are naturally connected by the all-purpose process of creativity. This versatile process encompasses critical thinking, real-world problem-solving, discovering, inventing and innovating. The ArtScience collaboration described in this White Paper, the "ArtNano" Project, shows how two collaborators, a visual artist and a pioneer Nanochemist, integrate their exploratory work and empirical research using one-and-the-same process of creative learning and idea-generation. The ArtNano project considers the potential of numerous practical innovations in the field of Nanoscience and Nanotechnology that are designed to meet today's global challenges and our collective quest to invent a sustainable future. It also reveals the difficulties of communicating complex information to a worldwide public—in particular, the myriad strategies and technological means by which human beings ingeniously manipulate matter on an atomic and molecular scale to produce the smallest, multi-purpose functional structures and systems ever conceived. The collaborators reflect on their personal experiences conceptualizing the artworks for this project, providing some essential lessons learned from combining their complementary practices of connecting and transforming information (data, knowledge, ideas, concepts, theories, etc.). Additionally, they offer some recommendations for moving beyond common roadblocks to collaboration that form from self-imposed mental barriers, as well as our compartmentalized ways of knowing the world, and representing our knowledge.

Complexity Art: A Pattern of Transdisciplinary Emergent Properties

Coordinator: Myriam Solar, Independent Researcher and Complexity Artist
http://independent.academia.edu/MyriamSolar

Abstract: On the global stage of the intersections of art, science, technology, and society seeks to transcend disciplinary boundaries with creativity and innovation. From the Helsinki agenda in 2004, through international collaborative project led by USA, England, Australia or further analysis on the role of international cooperation in a framework programme it is concluded that both in Europe and in the rest of the world it is from an emerging reality where partnerships are still incipient and fragmented by the obstacles that arise when trying to reach a common platform. The European framework of reference notes that, except isolated of international character initiatives, cooperation arises at Community level between science and technology and on a subsidiary basis between art, digital technology, sociology or political science, being practically non-existent interactions between experimental art of complex nature, science and nature.

The State of the matter forced to redefine the nature of the interactions from the art as well as to change the dominant model in relation to the global dynamics in order to remove some of the obstacles arising from a classic paradigm consisting of capture the simple and unchanging essence of things on the other in which shapes are organisms at a new level of complexity in their elements interact with each other in a process with emergent properties. This another paradigm with which I started 25 years ago my experimental work in the complex art, the emerging fields with the science of water, fractal geometry, inorganic chemistry, quantum physics, artificial intelligence and other disciplines were not accepted as areas of work in the arts or in the sciences, so research has had to perform independently without resources and with imagination. The situation has not changed in these decades and the detection of obstacles and opportunities displaying lead me to the need to develop a model that does not exclude research and direct practice with the knowledge objects common to science, art, technology, engineering, and other disciplines, thus extending the transdisciplinary paradigm to a model of emergent properties founded in dynamic processes of multiple interactions. This model is found in the art [and aesthetics] complexity capable of addressing objects as physical phenomenon integrated to other systems away from the balance and non-linear evolutionary process. In the new art model it ceases to exist as an inspiration of scientific principles or technique of application to the sciences to work as does natural organic world and, therefore, science. In this perspective, the art can be collaborative if science offers a margin of confidence to face such collaboration and abandon prejudices in a future perspective. It is find a rich way that explore borders from experimental practice where art assisted by science, technology, engineering or design and / or the science assisted by the art cease to be aggregates or complements one another to move to work with new strategies of interaction.

In this paper attempt to suggest that both the art and the science involved a common search to achieve an understanding of the world, therefore need to identify problems and opportunities, or support for the development of intersections in the emergence of the new mechanisms. To which

artists and scientists should know the fields of an eventual collaboration through a specific agenda for action which could include: the creation of a global digital registry that incorporate names, lines of research, calls for collaboration, funding for projects, curriculum external programs, incorporating the scientific method and principles of the Sciences of complexity in the teaching of the multidisciplinary arts make possible the development of a program based on the new model to build and refine. A new model brings with it necessarily a change of paradigm in collaborative work, a cognitive training art science for a third culture and the development of protocols based on new practices that tend bridges and transcend the boundaries between the various disciplines.

Can "Art-Science" Provide a Space for Engaging With or Providing Relevance to Traditional/Artisanal/'Non-Western' Knowledge Systems Which May Pave the Way for Greater Dynamism in Art-Science Collaboration in Societies Such as India?

http://wp.me/P2oVig-ap

Coordinator: Sharada Srinivasan

National Institute of Advanced Studies The art-science engagement in some non-western societies such as India has not been very wide spread (as has also been pointed out by some of the draft White Papers). As part of broader attempts to contextualize the role of art-science in developing societies like India and also to explore the reasons for why this area is not thriving as much as it could be within these contexts, this paper attempts to explore the nature of engagement if any of art-science with traditional/appropriate/artisanal knowledge systems in these contexts and how that could play an invigorating role. At one level, it would not be correct to say that there has not been art-science engagement in India of a high caliber there have been some outstanding examples of which have emerged out of design schools and through contemporary artists which have consciously attempted to engage with the most cutting edge aspects of art-science. However, this paper is not concerned with that aspect in the main, but more with the situation at the other end of the spectrum which concerns not so much the realm of high-science or mainstream science and contemporary art, which that of 'low'-science, which may include non-laboratory activities that nevertheless have a technological underpinning such as artisanal technologies, traditional knowledge systems, appropriate or rural and grassroot technologies and such like. This paper would like to explore the aspect that there are perhaps lacunaes in terms of the overall art-science debate of accommodating this aspect and perhaps such an engagement, would lead to more dynamism in developing the field of art-science. An example of such engagement that could be beneficial could be of metal working artisans interacting with students in metallurgical laboratories/classrooms, which at present is not envisaged as part of the educational system in a country which still has the largest artisanal base in the world and this paper would aim to explore whether such approaches would not have a stimulating effect in the context of art-science. At another level, perhaps the nature of modern scientific thinking has generally been such that it has not really generated much space for accommodating or living with alternate scientific and societal discourses from 'non-western' societies that may to some extent critique the universality or local relevance of these scientific paradigms or parameters especially from a developmental context. Thus it may be relevant to explore whether there are directions that the discourses on art-science may take which can engage with these directions as well.

Opportunities and Obstacles Facing Scientists, Mathematicians, and Engineers Deeply Engaged in the Arts and Design

http://wp.me/P2oVig-8k

Coordinator: Carol Strohecker

Working Group Members: Roger Malina, Wendy Silk, Bruno Giorgini

Scientists and engineers in a range of disciplines engage the arts and design for both personal and professional reasons. This SEAD White Paper goes beyond avocations such as painting or playing a musical instrument, to examine opportunities and obstacles that scientists face when collaborating with artists in professional work.

Overlaps among sciences/engineering and arts/design are widely acknowledged in terms of the shared motivations of questioning and creativity and the shared approaches of exploration and invention. Yet, practitioners who attempt collaborative work across conventional disciplinary boundaries often encounter inhibitory mindsets and institutional structures. Struggles may also emerge within the established partnerships: artists may feel exploited, desiring to contribute more than just illustrations; scientists may disengage through fear that the artists do not have adequate grounding to achieve necessary topical depth.

Nevertheless, many scientists manage to produce effective work through broadly cross-cutting collaborations. In this White Paper we propose to interview a number of scientists, mathematicians, and research engineers who have engaged deeply with the arts and design, to elicit a contemporary snapshot of perceived obstacles and opportunities from scientists' point of view.

We will include representatives of disciplines such as entomology, neuroscience, chiropterology, meteorology, computer science, and marine ecology. When the interviewees desire anonymity, we will maintain it. We will conduct some of the interviews through face-to-face meetings and some through email correspondence. We will address these questions among others:

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What is your scientific discipline?

What is your art form?

Do you combine any other scientific or engineering perspectives in your work?

When did you start involving artists and/or designers in your work?

What motivated you to do so?

How would you characterize the nature of the artistic contributions?

To what extent do the results facilitate:

breakthroughs in your understanding of the scientific problem;

new formulations of older paradigms;

new experimental approaches;

communication of your work to colleagues;

communication of your work to the general public;

public engagement with your work;

education of your students and colleagues;

education of the general public;

the scientific inquiry itself.

Do you have favorite results from your collaborations with artists/designers?

What has worked best in these collaborations?

Why do you think it worked well?

What problems have emerged?

What caused these problems to emerge?

Are there ways in which your institution facilitated or hampered your collaboration?

What new opportunities exist to be promoted ?

Have any patents resulted from your art-oriented projects?

Which results of the collaborative involvements most fundamentally changed your thinking about your science?

How has the involvement influenced your working method or approach in any way?

Has the work led you to inquiry of any other scientific problems or topics?

Any other thoughts about your art/science work?

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We expect that these questions will lead to back-and-forth exchanges in person and/or via email. We will sustain these dialogs in order to understand particulars of each collaborative situation. Finally, we will compare the responses and cull points leading to Suggested Actions for people seeking to develop art/science collaborations and for funders and policy-makers seeking to support them.

We invite interested scientists to contact us at:

Carol Strohecker <cs-at-centerfordesigninnovation.org>
Interview questions for broader-reaching scientists, research engineers, and mathematicians.

Broader-Reaching Scientists.pdf

Gender and STEM: No Shift Required

http://wp.me/P2oVig-gu

Coordinator: Deborah Tatar

In the past thirty years, several waves of opportunity have come successively closer to realizing Papert's vision of a world in which children can self-actualize as owners and creators of technology. Each wave, starting with Logo, has had strengths and limitations and while some have had considerable reach (FIRST Lego League, for example), none have as of yet become fixtures of childhood. Now, part of the opportunity that comes with a switch from a STEM to a STEAM perspective is the chance to build foundations for female—and more widespread male—participation in computing on a wide, humane platform in which the outside world is involving, inviting and discovering rather than persuading, cajoling and selling. In particular, recent tools associated with the Maker or DIY ("Do It Yourself") movement have the potential to increase embodied, craft-oriented performance-focused behavior. Girls (and a range of boys) can now create inexpensive personalized, crafted objects that cause them to rub elbows with technology and technological thinking without having to first (or ever) label themselves as one of "them," the kind of person that actually likes technology. They can tinker, both with creations and identity. They can develop skills which will help them no matter what they go on to do, and their relationship to those skills can change over time. The crucial opportunity, ironically, lies in the relative unimportance of the technology in defining the students' projects. Although tools such as Leah Buechley's sewable electronic components are new, the opportunities they present resonate with older successes. They have social and technological properties that have been to some extent lost with the rise of personal computing. In particular, the world of young people has traditionally included legitimate peripheral participation in activities that could be pursued in a more complex fashion by adults. Sewable electronic components permit just such activities. The threshholds to using sewable electronics, in particular, are very low. While some adult encouragement and guidance is required, the level is more comparable to that required for lanyard-making, crocheting, knitting or embroidery than most interactions with electronics. The physical dexterity to sew with large needles and thick thread is in most cases attained by early elementary age, and, at $2 for a sensor or actuator, simple projects are affordable by most families in the United States. Often tweens are in a position to earn enough money to fund more complex projects through activities such as babysitting. The activities can themselves be social, just as knitting is often a social act, and self-determined. Furthermore, with even modest mastery of the technology, outcomes can be a personal expression on the part of the maker. Not only can many products be worn, but, unlike most computational products, they can be given as unique and personal gifts from one person to another. At the same time, the desire to create more complex creations leads directly to a simple, and still relatively inexpensive path to computing. This is all very exciting. But note that supporting this requires an interdisciplinary perspective in which we pay more attention to the sheep than to the shearing. We would like more women to engage in STEM fields. There are a number of reasons for this. Some reasons have to do with the women themselves. It seems to modern American society wrong or unfair if women do not participate in equal numbers in elite vocations Some reasons have to do with various perceptions of the benefits of involving women in STEM activities. For example, NCWIT promotes on its brochures research showing that mixed-gender teams work better than single-gender teams. The

idea is that women should be involved in computing because they are needed. Notice that, in a brute force way, the desire to involve women equally stems from the belief that girls are essentially the same as boys, while the desire to persuade that they are needed entails the idea that women are somehow essentially different, that a women's perspective is a special contribution. So what are we women, and why are we wanted? This is very confusing, even if one considers women as a coherent group. It's more confusing if one considers the range of women and young girls, their hopes, dreams, and prospects. It is yet more confusing when one considers the range of high-school, college and work-place environments that we or they might encounter. These confusions themselves can contribute to the idea that participation in STEM fields is difficult. Furthermore, it is quite possible that participation in STEM fields IS quite difficult intellectually, emotionally, and pragmatically, especially for people who are on a different path. We would never say that all boys in society should become lawyers, and, likewise, we should assume neither that all girls would be better off if they went into STEM fields nor that society would be better off it they did. We want women to go into STEM fields, and the strategies we use most often are persuasion and focused demonstration. We should learn from one of the most successful educational enterprises of all: the enterprise whereby middle class (white) toddlers learn to love reading by being read to. The child appreciates the ball-of-wax in which s/he is held, talked with an entertained with world knowledge and pictures. If no other problem intervenes (such as dyslexia), one of the best predictors of reading in elementary school is being read to as a toddler. The solution I am proposing to women's involvement in STEM is not to encourage them explicitly at all, but instead to develop a deeply interdisciplinary approach to what constitutes the STEAM enterprise. In this approach, the technology is not there for itself, and its presence is unremarkable. Supporting the girl in activities that she chooses to do is central, and exposing her to a world in which these activities frequently involve technology use is a key ingredient. The challenge to this is that we live in a world which values the shearing more than the sheep—but the kind of girl we want in the STEM enterprise senses that.

Intellectual Property Issues Arising from Science/Engineering to Art/Design Collaborations

http://wp.me/P2oVig-73

Coordinator: Robert Thill, Roger Malina, and Audrey Pic

Developed in partnership with Arts Active, the international network
of art-science residency programs: http://www.artsactive.net/en/

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Open invitation : if you would like to be involved in the development of this White Paper contact rmalina(at)alum.mit.edu

We are also calling for volunteers who would be interested in volunteering time to organize and develop this White Paper.

Abstract:

Science, Engineering, Arts, Design and the Humanities have developed significantly different approaches for addressing intellectual property, author rights, and sponsor rights in inventions and creations. Sometimes these can lead to obstacles to information sharing Science/Engineering to Art/Design Collaborations, but also disputes and other impediments. Issues include credit attribution that can be important not only in commercial applications, but also in criteria for promotion of individuals within their organisations.

In addition e-culture is driving new and rapidly evolving IP systems, but also the new ethos of open source often recontextualises the way that collaborations are carried out. Issues of privacy and confidentiality can introduce other impediments to SE-AD collaborations.

In this White Paper we will:

a) Carry out a meta-analysis of Suggested Actions and recommendations concerning IP that have been made in prior reports that are in the SEAD report inventory (http://seadnetwork.wordpress.com/reports/). Recommendations from previous reports concerning IP are aggregated at (URL to be provided)

b) Point to existing on line resources concerning IP that can be used to guide collaborations involving bridging science/engineering to art/design/humanities (resources URL to be provided).

c) Accumulate case studies that illustrate the obstacles faced by collaborators. We are particularly interested in a variety of institutional contexts and international contexts. Case studies will be posted at (URL to be determined).

d) Accumulate relevant references re IP issues to be included in the White Paper Bibliography: http://seadnetwork.wordpress.com/bibliography/

e) Propose Suggested Actions not only to researchers and artists and designers but also to their institutional and other partners including funders.

We intend to publish the report in the open literature.

Case Study and Lessons Learned: Sauti Ya Wakulima, "The Voice of the Farmers"

http://wp.me/P2oVig-fi

Coordinator: Eugenio Tisseli

Sauti ya wakulima, "The voice of the farmers", is a collaborative knowledge base created by farmers from the Chambezi region of the Bagamoyo District in Tanzania by gathering audiovisual evidence of their practices using smartphones to publish images and voice recordings on the Internet. The participants of Sauti ya wakulima, a group of five men and five women, gather every Monday at the agricultural station in Chambezi. They use a laptop computer and a 3G Internet connection to view the images and hear the voice recordings that they posted during the week. They also pass the two available smartphones on to other participants, turning the phones into shared tools for documentation and observation. The smartphones are equipped with GPS modules and an application that makes it easy to send pictures and sounds to the Internet. The farmers at Chambezi use them to document their daily practices, make reports about their observations regarding changes in climate and related issues, and also to interview other farmers, expanding thus their network of social relationships. The farmers at Chambezi not only struggle because of insufficient infrastructure and unreliable markets for their products, but they are also facing the challenges of a changing local climate. Less rains, less underground water and unprecedented threats caused by pests and plant diseases are some of the pressing issues that they have to deal with. However, they know that by sharing their knowledge on how to cope with these problems, they can become stronger and find ways to overcome them. They hope that, by communicating their observations to extension officers and scientific researchers, who can be in remote locations, they can participate in the design of new strategies for adaptation. We will draw the lessons learned from this project for future projects of this type.

Core Concepts: A Model Curriculum for Collaborative Creative Research in Art, Design, Engineering, and Science

http://wp.me/P2oVig-oB

Coordinator: Meredith Tromble, Associate Professor, School of Interdisciplinary Studies, San Francisco Art Institute

August 15, 2012

David Bates, Director, Berkeley Center for New Media, University of California, Berkeley
Jesus Beltran, Filmmaker, Zumpango Films and Mechanical Design Engineer, Palo Alto
Marina McDougall, USA
Sarah McMenamin, Postdoctoral Fellow, Evolutionary Biology, University of Washington, Seattle
Miriah Meyer, USA
Susan Schwartzenberg, Senior Artist, Exploratorium, San Francisco

"...knowledge has to be organized so that it can be taught, and it has to be reduced to information so it can be organized...this leads you to assume that organization is an inherent property of the knowledge itself, and that disorder and chaos are simply irrelevant forces that threaten it from the outside. In fact it's exactly the opposite. Order is simply a thin, perilous condition we try to impose on the basic reality of chaos..." ! !
— novelist William Gaddis

There is now a significant opportunity to investigate the relationship between contemporary scientific research and contemporary art, recasting our understanding of their relevance to each other in terms that bear on university education. Contemporary art's emphasis on critique, invention, paradox, and nonlinear thinking has made it an uneasy fit for educational systems rooted in a rational, modernist world view. Widespread cultural mythologies about the creative process, inflexible disciplinary silos, and metrics of assessment rooted in 19th century conceptions of knowledge continue to make art a misfit in university curricula. But scientific developments — in complexity and network theory, neuroscience and cognitive theory, evolutionary biology and social theory, all underpinned by digital technology — offer the opportunity to discuss and assess art in new terms. At the same time, in contemporary art the notion of art as inquiry, as a form of research, has taken hold. Art offers a "laboratory" for exploring issues such as the role of images in social intelligence and individual mentation, embodied cognition, decision-making processes based in intuition, and the conditions that nurture innovation. This White Paper will outline areas where research in contemporary art and science might intersect, take into account significant differences in their research practices, and use this outline to frame a model cross disciplinary curriculum designed to prepare artists, scientists, engineers, and designers for fruitful collaborations. A draft will be formulated and circulated to a pool of advisors including educators in each of these areas, and their feedback factored into the final paper.

Chaos, Computers, and Cyborgs. Developing the Art and Technology Practices in Taiwan

http://wp.me/P2oVig-gD

Coordinator: Yu-Chuan Tseng (Taiwan)

Antoanetta Ivanova (Australia/Taiwan)

The history of Art & Technology practice in Taiwan can be traced back to the late 1970s when the first 'Laser Promotion Association' meeting was held in 1977. The aim of the event was to introduce laser art to Taiwan. It was a small, specialized field limited to research and development projects with no public outcome. At that time there were no cultural institutions which would support the exhibition of such art. In 1988 the Taiwan Museum of Art (now National Taiwan Museum of Fine Arts) was inaugurated. One of its early exhibitions was "High Technology Art" featuring Kinetic Art, Video Art, Laser Art, Computer Graphics and Cyber Art. In 1990, upon returning from her studies in Japan, one of the most influential Taiwanese cyber artists, Peisuei Lee, staged the exhibition "Computer Art". In 1992 she published a book also titled Computer Art: a compendium of Peisuei Lee and Yoichiro Kawaguchi's computer artwork "Fractal". Through these seminal projects "computer art" was asserted as a legitimate term noting the emergence of the new media art form in Taiwan.

Some of the key mile stones in the development of the Art&Technology field of practice include the 2004 exhibition "NAVIGATOR: Digital Art in the Making", realized under the auspice of the Cultural and Creative Industries Development Plan's, Digital Art Promotion Program of the Council for Cultural Affairs, Executive Yuan of Taiwan (now Ministry of Culture). The exhibition introduced trends in Western digital art, showcasing the integration of digital technology and art. The intention of the project was to stimulate the local discussion of digital art within academic and creative circles.

Today the Ministry of Culture and the National Culture and Arts Foundation provide grants for the creation and dissemination of Art & Technology projects. Taiwan's digital art festival is held every year by the Digital Art Center. In 2012 audiences in Taipei were treated to a wonderful selection of digital media works at the Digital Performing Arts Festival. There is now a third generation of Taiwan artists working with digital media. They are becoming increasingly sophisticated as well as diverse in their approach to Art & Technology practices. However a consolidated cultural policy at government level needs to be developed and implemented if the energy and innovation of Taiwan's media art creatives is to be sustained.

These local challenges are not dissimilar to other parts of the world where this field of art practice is developing: primarily limited resources, little or inadequate support from major galleries, lack of curatorial expertise; narrow education and research programs; not sufficient public debate and critical review. The Art & Technology White paper on Taiwan will focus on the achievements as well as challenges concerning local practitioners. It is hoped that some concrete recommendations can be made with respect to the development of this field in Taiwan.

Process Driven Potentials for Interdisciplinary Learning:
Ubeats, a Model for Science and Music Learning

Coordinators: Cynthia L. Wagoner, Ph.D., East Carolina University, and Robin Wilkins, PhD student in Neuroscience of Music,The University of North Carolina Greensboro

National policy makers, economic stake-holders, and learning advocacy professionals recognize the critical importance for young minds to develop as scientifically grounded, yet cognitively flexible. Creativity, the mind's ability to link previously unconnected and often disparate concepts into a useful idea, is now recognized as inherently linked to interdisciplinary situational learning. The challenge for the arts and sciences is to reevaluate their inter-relationship and to explore collaborative new methods in investigative learning. The generation of new knowledge grounded in interdisciplinary concepts and methods is what will generate a co-created future led by scientists and artists. To achieve this goal, both the arts and sciences must reconsider traditional processes and methodologies that lead to curriculum-in-isolation. Disciplinary driven, yet artificial, barriers that unnecessarily prevent children from experiencing the potent and rich environment found within multi-modal and interdisciplinary learning must be challenged.

The next step in 21st Century learning is found at the intersection of arts and sciences. Whereas the science community seeks more ways to engage young students, the arts have often been able to easily engage students, yet without substantive inquiry. Finding a new model is the key. One example of a fully integrated interdisciplinary curriculum is UBEATS, a seamless science and music curriculum that utilize both science and music to provide creative problem solving activities and concept building. Using a BioMusic framework, both teachers and students benefit from interdisciplinary study in the following ways.

First, UBEATS is learner-participant driven, utilizing the experiential nature of both music and science. Second, the curriculum integrates knowledge of both subjects in a way that encourages student-driven original ways of thinking while simultaneously scaffolding new knowledge. Third, the curriculum design utilizes the embedded relationship between music and science to raise questions and create dynamic problem-solving activities, eliminating fragmented and disconnected scientific learning. And finally, teachers are able to differentiate instruction and utilize rich assessment methods, further enhancing broader classroom goals of literacy, numeracy, and individual and planet health and wellness.

Unfortunately, gaining ground in the elementary schools for such a curriculum has been relatively slow. Specific issues include but are not limited to: lack of contact time with students, resistance to teacher-to-teacher collaboration, and misinterpretation of in-service efforts. Primarily, the perception of doing more, even if it is beneficial to their students, often is reported as impossible. Beyond the planning, even given a fully developed curriculum package, there is teacher time and investment in materials required for the classroom each year.   Given the deprived financial and time-structure environment of school reform, the pressure to produce strong test-takers has been the overwhelming requirement. Notwithstanding, teachers acquiesce the advantages of UBEATS interdisciplinary work.

However, positive views of interdisciplinary, multimodal and inquiry-based learning must be cultivated simultaneously from the ground up and top down within the educational system. Despite the successful piloting of UBEATS, receiving full administrative support has yet to be achieved. Further, those previously, educated within the university structure of isolated disciplines have more resistance than teachers who have been exposed to this curriculum in a summer session. Therefore, pre-service teacher exposure to the program is essential. Overall, responding to pre-service teacher needs, receiving administrative and university support, and receiving funding are the current challenges to genuine interdisciplinary, multimodal curriculum.

A Study of Art/ Science Collaboration in China and its Neighbors

Coordinator: Annie Wan

Scientific inventions of Ancient China are immensely important to our global culture and everyday life, while traditional artworks (paintings and sculptures) possess a long history in China. In this time of economic boom in China and its neighbors, science finally meets arts in various ways, such as usage of fireworks and gunpowder in Cai Guo Qiang's works, interactive art by Feng Mengbo, etc. This paper consists of interviews with artists/ engineers in China (and its neighbors) and their perspectives of art/ science collaboration in this societies. The research analyzes differences and similarities between practices in China (and its neighbors) and that in Western countries. It also investigates their definitions of technologically-assisted art and potential problems in art/ science collaboration. Lastly, it foresees how to extend the boundaries of current art/ science collaboration practice, suggests both possible conceptual and technological developments to artists/ engineers and academia.

A Case Study on Being Both and Neither: Self-Organizing Art-Science Collaborations Functioning Outside Institutional Structures

http://wp.me/P2oVig-fL

Coordinator: Ruth West

This case study presents the experience of two large-scale self-organizing art-science collaborations that arose outside of institutional structures while functioning effectively and productively within academic environments. Collaborators included artists, researchers, graduate and undergraduate students, and spanned the disciplines of new media arts, bioinformatics, computer science (vision and graphics), engineering, proteomics, comparative genomics, metagenomics, english literature, calligraphy, 19th Century naturalist illustration, visualization, music composition and data sonification. In each case, the working process evolved over several years and included external consultations with subject matter experts, as well as collaborators that joined the core group for brief periods for specific purposes. Both groups shared the over-arching goals of creating work that contributes simultaneously to the realms of art and science while retaining discipline specific rigor, to investigate the nature of interdisciplinary collaboration, and to explore how artistic practice and aesthetic experience can nurture scientific discovery while simultaneously exploring, articulating and instantiating new cultural forms. The collaborations developed work presented in arts/cultural venues as well as publications presented in scientific and arts conferences. Lessons learned include evolving group identity and structure and towards an integrative and iterative co-creative working process. Challenges include establishing reciprocity in hybrid practice, shifting roles and identities when bridging disciplines, facilitating communication, and funding and sponsorship.

Describing Changing Curricula

http://wp.me/P2oVig-8G

Coordinator: Roy Williams

Jenny Mackness
Simone Gumtau

Education is built on the foundations of peer reviewed knowledge, first formalised in the Royal Society many years ago, so networking in academic communities is nothing new. What is new is the facility for networking offered by the internet – global, mobile, and in principle open. It is now so much easier to explore "tools, information, resources and points of view from other disciplines that can elucidate and even answer problems" that you might be studying.

This provides opportunities and challenges for the curriculum. Institutions, through their courses, and students and staff, through their networked learning and research, are all trying to find ways to reconcile core curriculum values and standards with these rich, serendipitous, and sometimes centrifugal, forces.

We have identified a number of problems and opportunities arising from rapidly evolving new curricula in particular, which arise in teaching that links science and engineering to arts and design. We propose new methodologies and approaches that may help to address the new situation.

From the perspective of curriculum design, evaluation and research, one of the first challenges is how to describe and track these changes and the way they affect teaching and learning, both within the emerging curricula, and within curricula which are themselves emergent. Emergent curricula can change during a course; they are no longer defined solely by the providing institution, but rather by the interaction between what is provided by the institution and the initiative and networking of the students, as their learning crosses traditional institutional and disciplinary boundaries.

Describing these dynamic changes is the subject of a paper on 'Footprints of Emergence', forthcoming in IRRODL (International Review of Research on Open and Distance Learning). It is based on a paper in 2011 in IRRODL1 on Emergent Learning and Learning Ecologies. These dynamic changes are complex, so to do justice to them, we developed a new footprint template, based on our research into a range of very different courses and learning events. The template was proofed and tested in a workshop where the participants mapped out their own teaching or learning, and used the footprints they had drawn to inform discussions about their curriculum, and about emergent curricula.

This 'topography of learning' is a rich, three dimensional visual template, which enables us to map out, describe and explore the complex relationships and dynamics of adaptive, co-evolving, curricula and courses. For the first time, perhaps, it also explicitly integrates and acknowledges the value of prescribed learning: the central repository of core knowledge. The topography

provides a visual framework and metaphor for exploring how and why learners move back and forth between prescribed learning and emergence. It can be used for strategy, design, course management, feedback and feed-forward, and critical reflection – by both students and staff.

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Interested people can contact us for further information, in the first instance at: roy.williams@port.ac.uk, and I will forward comments and queries to my collaborators.

1. Emergent Learning and Learning Ecologies in Web 2.0, IRRODL 2011 (http://www.irrodl.org/index.php/irrodl/article/view/883/).

A Strategic Experiment for Promoting a SEAD Community Collaboration: A Machine for Testing Whether it is Possible to Teach Biochemistry to Non-Scientists

http://wp.me/P2oVig-9L

Coordinator: Dr. Jonathan Zilberg, Research Associate, Department of Trans-technology, University of Plymouth

Dr. Barry Kitto, Professor, Department of Biochemistry, University of Texas at Austin

This collaborative position paper establishes the framework for creating a trans-disciplinary community committed to participating in a learning experiment, specifically an integrated SEAD biochemistry project. The strategy proposed here is to use creative means to introduce non-scientists of all ages to basic biochemistry. The logic is that by using an aesthetically interesting and creatively engineered embodied learning experience, the Krebs Cycle can be understood by those with no previous background in science and chemistry – contrary to current pedagogical logic in science education. The purpose of this paper is to document an emerging SEAD community collaboration which will ultimately engineer and test this hypothetical learning experiment.

The pedagogical and philosophical applied principal is that this engineered learning experiment will bring biochemistry to an audience which would otherwise never be introduced to such advanced integrated understandings of chemistry and biology. Hypothetically speaking, a general audience should be able to understand this, the most elemental of the biochemical cycles if it is presented in a sufficiently engaging and accessible way. The goal is that the experience would stimulate greater interest in science and provide a heightened sense of appreciation for biochemical science in a nonintimidating, non hierarchical and trans-disciplinary way. Once the future student has a sense of the whole, the horizon for science education is potentially significantly opened to broader audiences than is currently the case. At the same time, being a trans-disciplinary project, it is designed to enhance biochemists' and biochemistry students' ability to conceptualize the structural, synergistic and energetic dynamics of the molecular transformations and processes involved in such cyclical chemical processes.

This project based collaborative strategy paper is designed as a White Paper towards attracting additional parties interested in participation in such an experiment, particularly Innovation Learning Centers and Integrated Science Departments. To begin with, the project concept, having been in discussion for many years, has now been formalized. It is being led by a senior biochemist similarly interested in the arts and public education and a social scientist and museum educator with an undergraduate background in biochemistry and applied museum experience in embodied learning and the arts. The SEAD paper will describe the idea and its evolution. It will include discussion of the science and the basic engineering and design required to build and test the machine, as well as the pedagogical logic involved. It will document the emergence of a community of creative individuals from across the SEAD disciplines ideally including engineers, designers, musicians, choreographers and artists who could contribute to the engineered aesthetic experience.

Ultimately the aim is to secure funding and build a collaborative network for testing whether it is indeed possible for non-scientists to develop a basic understanding of the Krebs Cycle through a physical learning experiment or the alternative forms. The three alternative forms for testing this pedagogical experiment with the Krebs Cycle include a board game, a computer game and a dance – The Dance of Life. In describing the ongoing efforts to create and test these prototypes and experimental learning contexts, the paper will document the roadblocks, constraints and thus opportunities which are presented by such collaborations and experiments. To be specific, the action plan is to build acollaborative SEAD community and to design and ultimately test experimental modes of science learning using embodied and aesthetic means.

Each step in the Krebs Cycle will be depicted on plexi-glass pressure plates on the museum floor. As one jumps from one molecule in the cycle to another, its name and two-dimensional molecular structure is lit up in the plate and projected onto the surrounding circular walls. The name of the molecule is voiced and it will ideally also made visible in three dimensions and in rotational motion. The byproducts generated or incoming molecules, each carbon dioxide, oxygen, ADP and ATP molecule, each co-enzyme involved and phosphorylation processes will be accurately depicted including the transformation processes. As the individual jumps or dances from panel to panel, moving around and around the cycle, they will actively acquire this scientific knowledge through an embodied learning experience. Particular attention will be paid to the integration and progression of the music and visuals in such a way as to make it a highly appealing sensory and artistic experience. As a site specific performance art work in its own right, it would be tested in different international contexts with preand post-testing of the learning outcomes. Ultimately, ideally, it would be tested in terms of incorporating it into a school science curriculum.

This is then a White Paper about a proposed learning experience. Considering the engineering and financial obstacles of designing such a science learning machine, and towards exploring the crosscultural potentials in play, the project also involves exploring a highly choreographed Javanese dance performance in with each dancer represents an atom, each molecule a group of interacting dancers, and each movement depicting the transformations involved at each step in the cycle. The dancers and the viewers, whether it be in the context of the machine in the museum or the dance in a theater would thus developed embodied understandings and memories of the Krebbs Cycle through a repetitive multisensate experience. For instance, in the case of the science or art museum context, viewers watching from a second floor balcony would indirectly gain the same knowledge through visual and sonic means. When no participants are using the learning apparatus, it would simply go through the cycle on autopilot. Thus the machine would be programmed to generate a continual aesthetic experience. An elemental engineering and artistic requirement is that in every step and every detail, the exact molecular and mathematical factors are accurate and cumulative, even synergistic but above all aesthetically compelling. For instance the all-important consequence of the reaction, the production of energy in the phosphorylation of ADP to produce ATP, and the mechanism of the ATP cascades releasing high energy phosphates, offer powerful opportunities for the visual representation of energy in motion, color and music.

The paper would also describe how in order to extend the experiment into classrooms, additional explanatory materials could be produced. For instance, printed and verbal explanations as well as an explanatory video of the purpose and logic of the experiment as well as other materials such as a board game, also in digital form, could be made available on-line for the purposes of a distributed emergent collaborative learning experiment. Naturally, the choreographed Javanese dance performance of the Krebs Cycle could be filmed and played continuously in a separate gallery in the science or art museum. Simply put, the paper will document the ideas being developed for a hypothetical SEAD experiment.

It is important to emphasize the pedagogical and practical logic driving this project. Globally speaking, with the arguably unnecessary rift between the sciences and non-sciences, too many people are simply unable to learn enough science so as to be able to ever get to the stage of developing a basic understanding of biochemistry. This is because of the necessary compartmentalization and hierarchy of the traditional learning process. If the process was inverted and in this way, synthesized at the start through visual and other means as an experience, students would be able to see the big picture to begin with. Through experiencing the wonder and aesthetics of the integration of chemistry and biology in biochemistry as a scientifically accurate all-encompassing art form, in this case with the iconic example of the Krebs Cycle, science could thus be made more accessible. In proposing this, the proposed SEAD experiment could ultimately make the cycle a subject of fascination for a large number of individuals to whom all of this would otherwise remain a life-long mystery and thus a significant limitation and roadblock to science education in general.

This kind of integrated, embodied and aesthetically enhanced learning experience is specifically designed to take the fear factor out of learning science. One key principle driving this project is that science is commonly seen as either too difficult or uninteresting and this amongst other factors unnecessarily separates the sciences, the arts and the humanities very early in the game. We lose potential scientists early in the educational process because of this factor and the years of study it takes before one develops an appreciation of the integration of the sciences. This is nowhere more fundamental than in the conjunction of biochemistry and molecular biology when all the basics including basic biology, math and chemistry come together. Accordingly, the logic of this SEAD experience is then to bridge the worlds of science and non-science.

The roadblocks, constraints and challenges for such a collaborative project are elemental. They extend far beyond the difficulties involved in securing funding and bringing together sufficiently interested and trained individuals capable of designing and engineering the physical, visual, sonic parts of the experiential learning machine. But should the machine ever be built, the board or computer games created and the Javanese inspired dance choreographed, practiced and performed to modified gamelan music become a reality, it would have been a direct outcome of this NSF SEAD White Paper.

This paper documents the emergence of a germinal SEAD collaborative community with a specific practical aim. The goal is to design, build and test an apparatus which would prove or disprove whether it is possible to teach relatively advanced science through a multi-sensory embodied learning experience. Both project leaders have previous experience in museum and

discipline based education. In that this project has evolved out of previous experiments as noted in the paper. Similarly, the basic principles at work will be related to theories of learning, the evolution of edutainment, embodied arts based education and more recent digital based on-line learning environments more generally.

The paper is at pains to identify roadblocks including technical and cultural issues. Briefly put, they are as follows. The roadblocks to this project are not hypothetical. They are based on many years of unsuccessful attempts to secure support for this experiment in innovation centers in the US, UK and Asia. The established position appears to be that it is not realistic or possible to teach something as advanced as the basics of biochemistry to a general audience whether or not one uses such an unusual experimental technique. Moreover, the complexity of the engineering and art relating to the integration of sound, image and experience requires considerable collaboration. Most problematic of all, it would involve significant expense. Furthermore it would require working across disciplines and institutions including the business sector. It would involve the collaboration of a group of individuals who would ordinarily not creatively interact especially to these specific goal oriented science and arts educational ends.

Innovation Learning Centers are in effect SEAD institutions and thus the perfect context for testing such an experiment. However, there are many exciting developments underway globally for artsand sciences collaborations and these provide any number of potential contexts for realizing this kind of project. One expected outcome of this paper is then that the mere fact of formalizing the idea and building a germinal network to expand its scientific and pedagogical basis, its design and institutional reach, will lead towards securing a testing context.

As regards cultural and inter-national issues, the point behind this project is that science education of this sort is value-free and is relevant in the same way to all students and scientists regardless of the cultural or national context. The aim is to advance science education particularly in contexts where is increasingly under threat through the erosion of educational funding and religious conservatism. In addition, even in the social sciences and humanities sectors in contexts where science is an area of intellectual interest and critical analysis, all too often the basic logic of science and what it involves, its practice, is misunderstood and under-appreciated. This is the direct consequence of a lack of sufficient training in science across the disciplines and thus knowledge of what is at stake in the issue of fact versus fiction and interpretation. This potentially impacts on something like the Krebs Cycle as it is a chemical process and not simply a discourse about what scientists imagine is going on at the cellular and molecular level. The importance of such issues will naturally also be commented upon in the paper in terms of roadblocks and obstacles.

This SEAD biochemistry project is led by a social scientist with training in science and a scientist who is also an artist. It is co-led by Dr. Barrie Kitto of the Department of Biochemistry at the University of Texas at Austin and Dr. Jonathan Zilberg who was trained in Dr. Kitto's lab and where this project first was conceptualized in the early 1980's. Both project directors have applied interests and experiences in art and in science education in museums in different national and international contexts. Zilberg is affiliated with the Department of Transtechnology at the University of Plymouth, with the Center for African Studies at the University of Illinois at Urbana-Champaign and in Asia with the National Islamic University of Indonesia in Jakarta

(Universitas Islam Negeri Syarif Hidayatullah). The project therefore has considerable potential national and international reach. Finally, the names and institutional affiliations of the collaborators joining in this project will be noted in the paper and their contributions duly noted as will be any opportunities which may emerge as a result of the preparation towards publication of this NSF SEAD White Paper.

Biological Arts

http://wp.me/P2oVig-eP

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Current trends in the life sciences and their related technological and engineering disciplines have a potential to fundamentally and radically change the way humans relate and treat life. This requires a cross-disciplinary effort to deal with the emerging cultural, epistemological, ontological and ethical issues of the new approaches to life. There is a need to culturally scrutinise the transformative power of the life sciences and engineering, to better understand and articulate a situation that seems to lack a cultural language. This paper will follow the developments of two examples of artistically driven cross-disciplinary initiative to engage, hands-on, with the life sciences and its related technological and engineering disciplines. The first is one of the earliest attempts to get artists to research and develop life science projects from within a biological school at a research university- SymbioticA- The Centre of Excellence in Biological Arts, School of Anatomy, physiology and Human Biology at The University of Western Australia and the second is one of newest initiatives in this area – the Art & Biology Lab (working title), at the Future Art Base, School of art and Design, Aalto University, Helsinki.

Case study one- SymbioticA

http://www.symbiotica.uwa.edu.au/

SymbioticA was established in 2000, as the first research laboratory of its kind, enabling artists and researchers to engage in wet biology practices in a biological science department. SymbioticA is an artistic laboratory dedicated to research, learning and critique of the life sciences. It is the first research laboratory of its kind, in that it enables artists to engage in wet biology practices in a biological science department. With an emphasis on experiential practice, SymbioticA facilitates research and actions which constitute cultural scrutiny regarding shifting perceptions of life, through better understanding and articulation of artistic ideas around scientific knowledge and informed critique of the ethical and cultural issues of life manipulation. The focus on experiential engagement with life led SymbioticA to develop programs that would allow artists, designers and other humanities and social science researchers access to labs and techniques usually reserved only to scientists and engineers. SymbioticA offers the only Science based Masters of Biological Arts, as well as undergraduate units and higher degrees (Masters, PhD) by research.

With more than twelve years history, around eighty residents' researchers and scores of research projects, SymbioticA can offer a range of case studies concerning models of art and science/engineering collaborations and mentorships. SymbioticA's bottom up formation and ongoing activities can also suggest lessons concerning STEAM.

Using SymbioticA as a case study will cover areas such as:

▪ Location- physical and disciplinary
▪ Academic – learning, teaching and research
▪ Core principals
▪ Collaboration vs. mentorship
▪ Research vs. production
▪ Funding

Case Study Two – Art and Biology Lab, Future Art Base, School of art and Design at Aalto University:

The Art and Biology Lab in the Future Art Base, School of Art, Design and Architecture at Aalto University, will be opened in October 2012. This lab, differently to SymbioticA, will be established as part of the School of Art, Design and Architecture, and will be physically located at the School of Electrical Engineering, at Aalto University.

This initiative is a top down approach. One of the roles of the lab will be to link Aalto School of Arts, Design and Architecture with other Schools under the umbrella of Aalto University, which is the result of three universities merging in 2010: The Helsinki School of Economics, Helsinki University of Technology and The University of Art and Design Helsinki.

Steps to an Ecology of Networked Knowledge and Innovation: Enabling new forms of collaboration among sciences, engineering, arts, and design

Final White Papers

(Re)Structuring Innovation: Community-Based Wet Labs
for Art-Science Collaborations

Coordinators: Steven J. Barnes & Carlos Castellanos, DPrime Research

Collaborations between artists and scientists have yielded many notable innovations. Yet, such collaborations are generally underutilized, mostly due to the myriad obstacles faced by the partners entering into such collaborations. These obstacles include financial considerations (e.g., a lack of available grant funds), social and political tensions (e.g., between art and science, two communities that usually have distinct views about what constitutes valuable research), and professional standards (e.g., what the collaboration yields that is of professional value, such as publications or gallery showings). In this paper, the key issues and barriers to artist-scientist collaborations are detailed. Then, some tractable solutions are proposed.

This white paper is composed of three parts. The first part examines the barriers to collaboration via a dialogue between the two key stakeholders in an artist-scientist collaboration: the artist and the scientist. Since this paper is co-authored by one individual with scientific training (SJB) and one with artistic training (CC), and because we have been engaged in an ongoing artist-scientist collaboration, we felt this approach would be the best way of itemizing the issues involved in such work and revealing the essential tensions.

In this review we have decided to focus on those scientific disciplines that have been more resistant to collaborations with artists. For example, we are not interested in considering how we can improve collaborations between engineers or computer scientists and artists, even though we recognize that such collaborations have their own issues and obstacles, since such collaborations have a rich history (e.g., see Klüver, 1972). With the goal of determining why collaborations with other types of scientists, such as biologists, chemists and other 'wet-lab' scientists, are so challenging, the second part of this paper analyzes the differences between those scientific disciplines that have a more established history of art-science collaboration with those that do not. Such an analysis will reveal some of the shortcomings of current approaches to fostering art-science collaboration, and should also suggest some solutions.

The third and final part of this paper will present several lists of suggested actions for overcoming the various obstacles identified in the first two parts of the paper. Although that section puts forward many suggestions to deal with the specific issues raised in the earlier parts of the paper, our focus will be on suggestions that will have a long-term impact and address the major concerns of the stakeholders in art-science-collaboration. In addition, based on our analysis in the second part of the paper, we will focus on suggestions that foster better and more numerous collaborations between artists and wet-lab scientists.

Our most significant and overarching suggested action will be for the building of new semi-independent institutions that provide real physical spaces, furnished with the necessary relevant equipment, where art-science collaborations. We envision these as being community-based

collective art-science organizations whose function is to serve as open access wet laboratories--not unlike the 'hacker spaces' that have appeared in many cities around the world, but with greater focus on the biological sciences, as opposed to engineering and computer science.

Though our focus is on discussing this open wet-lab scenario as a long-term goal, we ground our discussion by referencing our own personal experiences running a wet-lab-based collective in Vancouver, Canada. We will argue that although the formation of such autonomous organizations is critical for fostering artist-scientist collaborations, their ultimate success will depend on forming partnerships with academic and other cultural institutions, as well as an ethos of community participation.

Part I: Dialogue Between an Artist and Scientist on the Artist-Scientist Collaboration

While the issue of art-science collaboration as an institutional question has been address before (see Pearce, et al, 2003), for this first part of the white paper we have decided to address the question via a dialogue between two key stakeholders in an artist-scientist collaboration: the artist and the scientist. Because of our backgrounds and because we have each been engaged in several successful and unsuccessful artist-scientist collaborations, we, the authors of this white paper, have assumed the roles of scientist (SJB) and artist (CC). The dialogue is broken down into several subtopics, as appropriate.

Introductions: The Artist and The Scientist

CC: My background is in music and sound production. I later moved into other areas, that can loosely be defined as conceptual art, systems art and/or interactive art

CC: I am interested in art that emphasizes ideas, intellectual interpretation and critical judgment, rather than a pure focus on craft and object contemplation. I am also interested in cultural theory, philosophy, and analyzing/critiquing technology's role in society--this led me to the arts and technology. One of my primary motivations in this field is my belief that contemporary science and technology are radically transforming the world. I believe it is crucial that the arts address the questions and challenges presented by techno-scientific research. By doing so, the arts can expand its boundaries and reach.

CC: The truth is that my collaboration with SJB is probably my first "true" collaboration with a scientist. Although I have contacted scientists to ask them questions, I think two primary factors have prevented me from doing this until now:

> 1. Approaching a scientist can be difficult for an artist. I simply wasn't confident enough in my "crazy" ideas to contemplate asking a scientist to collaborate with me. I guess I felt I would be wasting their time somehow.
>
> 2. Second, the structure of MFA programs tends to hinder or obstruct collaborations of any kind. You are often supposed to explain what your personal motivation is or what you are trying to "express." Accordingly, a slightly more rational and exploratory approach, such as has been true for my work with SJB, is

difficult to contextualize for a "traditional" art faculty. That said, I do feel that I had the backing my thesis committee to do art/sci work but didn't pursue it as much as I could have (probably because of point 1).

SJB: After some early training in the visual arts, I pursued several degrees and then a postdoctoral fellowship in Behavioural Neuroscience. During the course of my training I increasingly became (re)interested in the arts and how the technologies I was using in my scientific discipline might be employed in the arts. Yet, when I looked around my wet lab, there was a stark contrast between the lab and the arts world. I decided to leave the sciences to pursue artistic endeavors. I pursued training in new media in the form of a postdoctoral fellowship in interactive arts. Since then I have been developing my own art practice (traditional drawing and painting, as well as some computational pieces) and have been involved in several artist-scientist collaborations. In such collaborations, I have mostly served in the role of the scientist (often, to my chagrin), though there have been collaborations where I felt I was contributing as an artist as well (e.g., my work with CC).

SJB: My background, accordingly, is admittedly different from other scientists that might be entering into an artists-scientist collaboration. However, I believe these dual hats I have worn have both better prepared me for collaborative work and furnished me with insight into the collaborative process itself.

DPrime Research and Biopoiesis

CC: Over the past two years, SJB and I have been involved in the development of a nonprofit community-based organization that incorporates scientific research from many disciplines (e.g., biology, electrochemistry) that have not commonly been a part of artist-scientist collaborations. We have been working to build an organization that is in the spirit of the hacker spaces (which largely focus on electronics, robotics, and programming) situated in many cities around the world, but with greater emphasis placed on wet-lab sciences. It is our hope that we can develop a community of artist/scientist researchers that will be engaged in activities that spawn the same innovation that has been coming out of community-based hacker spaces. The name of our organization is DPrime Research (www.dprime.org).

SJB: DPrime Research is definitely a multifaceted organization. We are part research and development think tank, part science and technology start-up and part cultural and community organization. We are an assembly of artists and academics.

CC: The first significant projects to come out of DPrime Research is a project called 'Biopoiesis.' Biopoiesis (dprime.org/projects/biopoiesis/) is a series of experiments exploring the relationships between structure, matter, and self-organization, in what might be described as a computational "primordial soup." This work built on cyberneticist Gordon Pask's research into electrochemical control systems that could adapt to certain aspects of their environment (see Pask, 1960). Our experiments, undertaken by SJB and I, explored the artistic potential of Paskian-like systems. This work also examined the interactive and computational possibilities of natural processes, the potential for natural processes to serve as an alternative to the commonplace digital forms of computation--which might help (re)establish a dialogue between

cybernetics, mainstream science, and the arts. In short, it was truly an artistic piece with solid scientific qualities.

SJB: Besides being a laboratory for explorations into electrochemical computing, Biopoiesis had at least two other purposes. First, we wished to feature and investigate alternative models of electronic arts practice (thus furthering the goals of DPrime Research). Second, by studying the growth and adaptation of an "inorganic" system, we wanted to question the traditional dichotomies of organic vs. inorganic and biological vs. non-biological. Based on the success of our public exhibitions of the Biopoiesis experiments, we felt that this body of work opened up new ways of thinking about sensing, intelligence (environmental, collective; not just cognitive), and memory (mutable electrochemical traces).

CC: Having provided that background about ourselves, our organization, and one of our projects, we will now talk about several topics related to artist-scientist collaborations.

Misunderstanding of the Other Discipline

CC: I think a major barrier to a successful artist-scientist collaboration is the existence of misconceptions of the other's discipline, a misunderstanding of what it means to be labelled (or self labelled) as an artist or as a scientist, or both. There is bound to be some level of miscommunication or misunderstanding, but insofar as the artist and/or scientist is not 'fixed' in their view of the other's discipline, the collaboration is much more likely to be truly collaborative in nature as opposed to being merely one sided.

SJB: The reason art-science collaborations are so challenging, or are never even initiated, is because the artist and scientist enter the relationship with two completely different conceptual models--both in terms of what they are trying to build, and how they should go about building it.

CC: I think that for an art-science collaboration to really work, it is not enough to merely throw an artist and a scientist into the same room. I would argue that the success of an art-science collaboration will depend on the appreciation that the artist and scientist have for each other's discipline. So, to maximize potential, each party must take steps to understand the world view and language of the other discipline, while leaving their preconceptions about art or science at the door.

SJB: In general, I think the common idea of 'collaboration' needs to be revised when applied to collaborations between artists and scientists. The common notion of 'collaboration' usually entails a worksite metaphor: If you bring your carpentry skills, I'll bring my masonry skills, and together we'll build a house. There is no need for me to learn how to frame a house, and there is no need for you to learn how to mix and pour cement; there must be a certain level of communication between our disciplines, but as long as we agree on the blueprint we can essentially get the job done with minimal interaction. This approach will not work in an artist-scientist collaboration as understanding the others discipline is so critical to the success of the collaboration.

The Non-collaborative Nature of Artist-Scientist Collaborations

SJB: So the term 'collaboration' might in itself be a source of confusion. Artists have told me they have wanted to collaborate because of my scientific background, but the collaboration turned out to be largely one-sided (and, hence, not in a collaborative spirit): I would end up fielding questions about this scientific topic or that, rather than engaging in any real collaborating (at least it wasn't the sort of collaboration I am familiar with from my work in scientific laboratories). The problem, I think, is that in many cases the artist doesn't want to collaborate with a scientist; rather, they want a quick way of querying the scientific literature. This is, of course, tantamount to merely examining the products of science, rather than collaborating with a practitioner of science. On that note, I would assert there are far fewer examples of art-science collaborations than most would believe--most are probably just examples of an artist exploring the products of science.

CC: Artists (like scientists) are very curious. I know that I ask scientists many questions (I know I ask you a lot of questions SJB). Some artists will approach a science-based work (such as a residency in a hospital or at NASA) almost as if they are a "spy" or "infiltrator" (in the nicest possible connotations of those terms). It's a knowledge gathering or fact-finding expedition; they are almost acting like a reporter. They simply observe what the researchers do and sometimes will use their equipment as a basis for their "traditional" artworks (for example Susan Aldworth who used functional magnetic resonance (fMRI) images of epileptic patients (among others) to make films, etchings and aquatints; see http://susanaldworth.com). While there is significant interaction involved (in her case with both patients and doctors and researchers), it is not a collaboration (in the sense that we are talking about).

SJB: My own impression has been that collaboration within the sciences might be a truer form of collaboration--where all collaborators get a chance at credit for what they contribute to an experiment or series of experiments. This is not necessarily the case in the arts, where there is still the tendency to view the artist as a singular entity. In most of the artist-scientist collaborations that I have been involved as a scientist, my somewhat cynical perception has been that the artist objectified me as 'scientist,' and that objectification was usually based on a popular view of what a scientist is and does (e.g., information tome, conservative, an unwavering believer in the power of objectivity). Even when collaborations have been balanced, others (e.g., curators) can impose their own preconception of the artist as a singular entity on the outcome of the collaboration--giving more credit to the artist for the final piece than to the scientist. For example, in a recent exhibit of Biopoiesis, the curator adopted this stance: Not having information from CC and I about what names should be tied to our piece, the curator decided to credit the artist among us (CC) for the piece.

CC: In fact, even in those cases where the scientist acts as mentor, or is otherwise integral to the realization of the piece, the artist will often not even mention that the scientist helped them (except perhaps in a credits listing which I believe belies the importance of the contribution). It struck me that most art/science (or art/engineering) collaborations generally fall into two broad categories: (1) scientist as mentor or even as a technician hired to a do a job (to help the artist realize his or her goals such as to make a glowing rabbit, or to program a self-organizing map algorithm (see Steinheider & Legrady, 2004)), or (2) artist and scientist as

"clearly delineated specialists" in their fields (e.g., an artist wants to brainstorm with a scientist to make something interesting from the scientist's research, such as a plant that acts as a pollution sensor by changing color which presents an interesting research problem for the scientist (this also gets to SJB's point of each bringing his own skills and world views)). In my view (2) gets closest to a "true" collaboration.

CC: So there are really very few "true" collaborations (like ours?) where both parties are exploring a new area together (e.g. cybernetics, electrochemical learning systems) without knowing the outcome ahead of time, primarily through subjective interpretations and ongoing conversations; both in a sense working as artists and scientists. Ideally, this would lead to both an artistic and scientific contribution by each member.

SJB: Yes, I agree. I think our work has the elements of a true collaboration. And I think there is an interesting distinction arising from this discussion. Namely, that between true and not-true collaborations. In fact, I think we can fairly distinguish between two sorts of collaborations: (1) mentor-based collaborations, and (2) true collaborations. Though we should acknowledge that (2) might in some cases still entail a worksite metaphor in the collaboration, as CC pointed out. Employing a worksite metaphor in this sort of collaboration is not ideal. However, at least from an innovation standpoint, it is certainly a truer collaboration than (1).

CC: Given that distinction, it is probably a good idea to throw out some examples and see whether we can neatly divide those examples into one or the other categories. Here are some examples of art/science projects.

- Eduardo Kac: Green Fluorescent Protein (GFP) Bunny: www.ekac.org/gfpbunny.html
- Victoria Vesna: Blue Morph: artsci.ucla.edu/BlueMorph/main.html
- SymbioticA: MEART: www.fishandchips.uwa.edu.au/
- Beatriz Da Costa: Experiments in Biosensing: www.beatrizdacosta.net/sensing.php

CC: While I have incomplete knowledge of how these projects came to be, I would say that generally, the first two are of the mentor-based variety we are discussing while the last two are closer to true collaborations, though they still have some degree of worksite mentality about them. Of course these categories aren't mutually exclusive, there is likely elements of both in each project.

SJB: How often is it that a scientist approaches an artist to have a collaboration?

CC: The answer is of course is never or almost never. The real question of course is why. Here, I think that the generally accepted response might be that scientists are either not interested in art, don't know how their work might be useful in making contemporary art or are simply too busy with their research and the pressure of teaching, running research projects, applying for grants, getting tenure, etc.

SJB: I suspect that the career advancement issues are the most significant. Another big issue might be the culture of science. During my training as a scientist, I know that in most cases my artistic practices were frowned upon as either being a waste of time or simply a quaint past time-

-nothing 'serious.' There needs to be a concerted effort by people interested in art-science collaborations to collect and disseminate those important instances where art-science collaborations have yielded clear benefits to the participants and/or to society. People need to be shown what can be accomplished with a true artist-scientist collaboration; otherwise, I can understand their reasons for being skeptical and hesitant to engage in one themselves. I am not sure if this is possible yet, given that there has been so little in the way of true art-science collaboration.

Career Implications of an Artist-Scientist Collaboration

SJB: The unfortunate reality is that although a singular scientist might appreciate one or more artistic endeavors, and may even be actively involved in them, the academic establishments within which they work usually do not recognize their efforts; thus, their collaborative efforts are not appreciated and may even be looked down upon by their scientist peers.

SJB: The artist has comparable struggles within their realm; for example, in the art world there has traditionally been less appreciation for the iterative, incremental work (that is much a part of a scientific practice), as opposed to the polished finished "masterpiece." This, of course, has been changing. Still, it is obvious that the issues extend well beyond the collaborators and includes the cultures within which each of those individuals work.

SJB: A key issue that stands in the way of artist-scientist collaborations is the disparity in the career benefits reaped from such collaborations. For the artist, such a collaboration is more likely to increase their academic and/or career stature through publications and gallery showings. For the scientist, such a collaboration is unlikely to yield comparable benefits. Some fellow scientists might even look down upon such endeavors. Moreover, such collaborative work, at least in its current form, is not likely to yield career advancement benefits in an academic setting for the scientist, where publications in scientific journals are the major indicator of making a significant contribution to their field of study. We need some mechanism of either changing the culture of science so as to encourage scientists to engage in collaborations, or we need to change the way that collaborations are structured so that the benefits from such a relationship are more balanced.

Process vs. Product

SJB: In theory, scientific practice is much more focused on the process of achieving some result and not just the result itself: the documentation of the methods of a scientific experiment or investigation is just as significant as the outcome of an experiment. One of the pillars of the experimental method is the importance of replication; the idea that the results of a single experiment are fallible, but with replications (ideally by different research groups) information distills.   Yet, in practice, there is good evidence that scientists (or at least the editors of scientific journals) are much more focused on the product. For example, positive results have a much greater chance of being published, and only a small fraction of published scientific experiments are ever replicated (see Lehrer, 2010).

CC: Traditionally, art's focus has been on the product. But this of course has been changing ever since the arrival of Conceptual Art in the 1960s, and the related practices of Systems Art and Process Art (all of which draw from Dada & Marcel Duchamp in some way). These practices, from which contemporary new media and interactive art derive, focus on the actual doing and how actions can be defined or understood as an actual artwork. So, in these practices, it's not so much about art as object but art as doing. But, as in science, the general bias toward "product" or the "object d'art" persists.

SJB: Yes, and it seems odd that the art world's move toward process over product has not been accompanied by the giving of credit to those individuals that an artists calls upon during the process of creating their work. Perhaps in conceptual art, the artist is still the key product? This is also not an uncommon part of the sciences. There are rock stars in both worlds.

CC: So there does seem to be some clear disparity between the methods of science and the methods of art. In science, there is objective detachment, in systems/process art there is (usually) a clear intention and desire to establish sets of patterns and associations - or at least set them in motion (even if, as in the case of John Cage for example, those patterns are not under the aesthetic control of the artist). There are differences as well: In systems/process art, replication and generalizability are generally not a concern. It can also be argued that traditional art-historical models of analysis do not apply; namely, appeal to the sublime or some aesthetic ideal (though I believe those are still there, just in a different form and with different emphases).

SJB: I agree, there should be an emphasis on exploration and discovery as opposed to merely following an existing line of research. For example, with Biopoiesis, we opened up some old abandoned work of the cyberneticists and explored those ideas in brand new contexts.

SJB: Despite science's focus on documentation for the purposes of replication, it seems very odd that science still largely relies on textual descriptions in journal articles as the primary method of disseminating the procedures used in an experiment. To the person that wants to replicate that experiment, there is nothing harder to decipher. Why aren't photos and videos used more commonly for the description of experimental methods? Indeed, there is only one journal that I know of that has employed a policy of documenting all research methods using video (i.e., www.jove.com/. Using video is probably seen as more demanding. But this is not a legitimate excuse.

CC: To be fair I've seen plenty of journal or conference articles in computer graphics, hci, tei, robotics, etc., where they at least link to YouTube videos.

SJB: It's interesting the disciplines you list as examples of properly documenting their process and methods. They are precisely those disciplines that have a richer history of art-science collaboration. Might this commonality in the proper documenting of process be one of the reasons for their heavy involvement with artists? Or maybe part of the reason the sciences you didn't list are not more involved in artist-scientist collaborations is because those sciences are seen as much more technically demanding and thus inaccessible--only by virtue of their methods being described in jargon-ridden journal articles, rather than through the use of video and images.

SJB: On a related note, it seems quite odd that scientists have not employed or sought guidance from artists how to better represent their methods (and to a lesser extent, their results) so that dissemination is more accessible, and replicability is improved.

CC: In general, I think what we are arguing for here is the establishment of autonomous zones of research where modes of exploration--highly speculative, without clearly defined goals, other than perhaps some loosely defined artifact or system (that is both an artifact of exploration and a vehicle for further exploration, as opposed to simply an art object in the traditional sense)--are brought to the fore.

CC: So the very models we are proposing in this paper (and exploring in current and future DPrime work) is itself an artwork or a research "artifact" or "result." The collaboration itself is the medium (see Slayton, 2002).

Part II: What Makes a Scientific Discipline Amenable to Successful Artist-Scientist Collaborations?

This second part of this white paper examines the qualities of those scientific disciplines that have had a significant history of working with artists and compares those disciplines with other scientific disciplines that have not had such a history. The purpose of this section is to achieve some assessment of what makes a scientific discipline more or less amenable to artist-scientist collaborations, or at least determine why certain scientific disciplines have seen more collaborations with artists. The question we hope to answer in this part of the paper is this: Why has computer science (in addition to certain engineering disciplines) seen such a relatively large number of artist-scientist collaborations when compared to wet-lab sciences?

Though there are of course exceptions, at least at an institutional level, the majority of artist-scientist collaborations in recent history have been between computer scientists and/or engineers and artists. The successes (and failures) of collaborative endeavors such as the Xerox PARC Artist in Residence Program, Interval Research Corporation and Experiments in Art and Technology (EAT) have been well documented.[1] This has likely been shaped by a combination of several factors, three of which we feel are the most important and warrant some discussion.

1. Access: First and perhaps most significant is the rapid and significant impact that computing and information technology has had on society. This does not entirely answer our central question, since there are many other scientific disciplines that have had a

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[1] The Xerox PARC Artist in Residence Program included renowned artist and scholars such as Stephen Wilson, Joel Slayton and Pamela Z (see Harris, 1999). Interval Research Corporation was a research think tank and technology incubator founded by Microsoft co-founder Paul Allen. It employed well known new media artists such as Brenda Laurel and Golan Levin among others (see Interval Research Corporation, 1998 for select publications). Experiments in Art and Technology (EAT) was a non-profit organization established to develop collaborations between artists and engineers and helped developing technology-based artworks that included such well-known artists as John Cage and Robert Rauschenberg among others. Notable engineers included Billy Klüver and Max Mathews among others (see Klüver, et al, 1972).

marked impact on society, such as the biomedical sciences. However, the advances made by computer science and allied engineering disciplines have the unique feature of having become very pervasive in the daily lives of most westerners. We are constantly exposed to digital media. It shapes our patterns of communication, our consumption and our social relations. By contrast, our exposure to biomedical advances has been less pervasive, or at least we are less aware of its presence day-to-day. This pervasiveness can, in part, be attributed to the relatively low-cost and accessibility of sophisticated digital technologies, in comparison to biomedical technologies which are often quite expensive and less accessible. This goes a long way in explaining why so many artists have explored the creative potentials of these technologies. Simply put, more artists can get their hands on sophisticated digital technologies than can get their hands on technologies of the wet-lab sciences (not to mention those of astronomy and particle physics). Although, at least in the case of the wet-lab sciences, there are many alternatives available to the technologies used in scientific laboratories--many of them in our own backyards, literally. However, those alternatives are often unknown.

2. Cultural Attitudes: The lack of access to the equipment and technologies of wet lab sciences general can, in addition to cost factors, also be attributed to a general cultural attitude of fear of wet lab sciences as potentially dangerous, toxic or life-threatening. The words 'bio,' 'biological,' 'genetic,' and 'chemical' all carry certain negative connotations that are related to their portrayal and usage in popular media. This might explain the rather byzantine labyrinth of concomitant policies and procedures that one must adhere to undertake many sorts of wet-lab sciences--often, when the hazards are trivial or non-existent. This includes the general difficulty in obtaining wet-lab equipment and resources when one does not have University-administered grant account or an industry account. While these barriers exist in all research areas, they are especially present in the wet-lab sciences.

3. Computation as a Medium: A final reason why computer scientists have been so involved in artist-scientist collaborations is perhaps because computation is seen as a medium. A computer has a more clearly defined set of input/output relations that simultaneously provide great variability and complexity (which is attractive to artist) but is also (in most cases) easily grasped by a non-technical user. Computer Science and Engineering are disciplines wherein the products (and process) are definite. There is no probability associated with the development of an algorithm. It either works or it doesn't. The answers these disciplines produce may be complex, but at the same time they are simpler in that they rest on firmer ground. Computer science and engineering have also produced tools that new media artists have used for quite some time now. It is perhaps more difficult to view the products of biological or chemical sciences as mediums that can be used by artists. Sciences that produce results that are attached to probability statements (e.g., $p < .05$) are perhaps harder to envision as being a fertile ground for collaboration. These results after all, do not do anything. If the reason that computer scientists are more commonly involved in artist-scientist collaborations is because their discipline has created a new medium for artists, then it should be the case that artists view their partner in such collaborations as technicians. Indeed, we feel that this is a common phenomena

in artist-scientist collaborations. This is perhaps what distinguishes between the mentorship-based and true forms of collaboration discussed above.

Part III: Suggested Actions

Given the issues identified in the previous parts of this paper, we would now like to suggest several lines of action.   In this part of the paper, actions are presented in subsections; each subsection is targeted at one of the many stakeholders identified for artist-scientist collaborations.

The most significant and overarching suggested action will be for the building of new semi-independent academic/industry/community institutions that provide real physical spaces, furnished with the necessary relevant equipment, where art-science collaborations can take place. We envision these as being community-based collective art-science organizations whose function is to serve as open access wet laboratories--not unlike the 'hacker spaces' that have appeared in many cities around the world, but that are focused more on the biological sciences, as opposed to engineering and computer science (though obviously a certain amount of crossover would be expected and encouraged).

I. For All Stakeholders

1. Support the creation of semiautonomous institutions--community-based wet labs--that provide support for artist-scientist collaborations and permit academic researchers to work outside their comfort zone, while free from significant worries about career advancement. Such institutions should ideally be situated in a neutral space and be outfitted with the equipment necessary for the artist and scientist collaborators to be able to draw from their disciplines and associated technologies. We propose that current hacker space organizations are a suitable model, but that there should be comparable organizations to support collaboration with all the scientific disciplines. For example, wet-lab hacker spaces for artist-biological scientist collaborations.

2. Pursuant to the above suggestion, limit as much as possible bureaucratic and institutional barriers to the founding and continued development of these institutions. Support decentralized, horizontal and community-focused organizational models.

II. For The Artist and Scientist Collaborators

1. Realize that your impression of your partner's discipline is probably incorrect, and enter the relationship as free of opinions and preconceptions as possible.
2. Realize that, although there may currently be career-advancement conflicts in many artist-scientist collaborations, such collaborations have historically been a great source of innovation. Innovations that you can carry you through their subsequent research career.
3. If you are engaged in an artist-scientist collaboration, take it upon yourself to educate your partner about your discipline and sub-discipline through readings and discussions. Educating your partner in the collaboration is critical to furthering the general goals of collaboration.

III. For Educators and Academic Administrators

1. Treat time spent within an artist-scientist collaboration as a criterion for career advancement in academic settings--both for artists and for scientists. Reward such risk taking, so that eventually it will no longer be risky and will be a standard element in career advancement schemes.
2. Universities should set up residency programs with established and to-be-established community-based wet labs, so that participants are given a clear record of their participation in the program (e.g., 'artist-in-residence' and 'scientist-in-residence' programs).
3. Acknowledge that much current innovation is occurring outside traditional laboratories, in (for example) community-based hacker spaces. Such existent organizations should be targeted as partner organizations, and new organizations should be founded to further innovation in those scientific fields where innovation is seen to be languishing.
4. Rework the assessment of academic accomplishment so that career advancement is not solely based upon numbers of publications in one's chosen field. Current career advancement mechanisms seem to favour non-innovative approaches (i.e., those approaches that yield higher publication numbers). Risk taking, exploration and innovation, in the form of artist-scientist collaborations or other activities, should be rewarded and not punished.
5. Support the creation of new academic journals (or the expansion of existing ones), based on the Leonardo model and the PLoS online publishing model (see www.plos.org/). Given that Leonardo (www.leonardo.info/) is already an excellent venue for general new media and art/science work, those new journals should be targeted at specific types of artist-scientist collaborative research.
6. Reward time spent in art-science collaborations with reduced teaching loads or comparable rewards, as is already done in certain universities to reward research productivity (usually measured by numbers of publications).

IV. For Foundations, Government Agencies, and Other Funders

1. Support the creation of new academic journals, as described above.
2. Allocate funds for the development of innovation through the support of specific art-science collaborations as well as the infrastructure to support those collaborations (e.g., community-based wet labs, new journals)
3. Institute granting programs that specifically call for artist-scientist collaborations--both at early and late stages of their careers. These grants could be used to fund residency programs in community-based wet labs, as described above.
4. Institute granting programs that reward time spent in art-science collaborations with reduced teaching loads or comparable rewards, as is already done in some current granting schemes.
5. Many grants are currently restricted to tenure-track University faculty. This restriction makes sense if one believes the tenure system to be an accurate means of assessing research ability. However, since the tenure system is biased against riskier forms of research that might not generate larger numbers of publications, this approach needs to be

questioned. Accordingly, grants should be opened up to individuals and non-profit societies.

6. Review any current regulations and laws that might be restricting or hindering wet-lab experimentation outside of the traditional University laboratory to determine if those rules still have any merit or are justified. It is quite likely that these restrictions and laws are slowing innovation.

V. For Industry

1. Provide funding, in the form of grants, for artist-scientist collaborations, and for the the formation of community-based wet labs. Understand that such funding will lead to innovative approaches to problems that you, as an organization, can set forth as the topics of grants. Also realize that your specified "problem space" has not been fully explored and that new problems (or the re-casting of old problems) may sometimes be the results of these endeavors.

2. Engage with the semi-autonomous institutions we are proposing. For example, by allocating time for employees to participate in the management of these institution or as a members of an art-science collaboration.

VI. For the National Academies, Scientific and Artistic Societies

1. Undertake or fund a comprehensive review of the works created through art-science collaborations and evaluate the outcomes of those works. It would be good for those involved in art-science collaborations to be able to provide evidence to support any claims that such collaborations serve as a significant source of innovation. As discussed earlier in this paper, it is our suspicion that collaborations that we have labelled as "true" collaborations are more likely to be the source of innovative outcomes; this assertion needs to evaluated.

2. Undertake or fund initiatives (e.g. conferences, community events, etc) that foster further discussions and knowledge sharing between artists, scientist and local communities.

3. Fund resources that provide information to aspiring wet-lab hackers about alternate and cheaper sources of wet-lab equipment, and alternate forms of items commonly used in wet labs (e.g., many chemicals that are expensive when obtained from chemical suppliers can be obtained quite cheaply through garden and home centers).

References

Harris, C. (Ed.). (1999). Art and Innovation: The Xerox PARC Artist-in-Residence Program. Cambridge, MA: The MIT Press.

Interval Research Corporation. (1998). Interval Research Corporation: selected publications 1992-1997. Palo Alto, Calif: Interval Research Corp.

Klüver, B., Martin, J., & Rose, B. (eds). (1972). Pavilion:Experiments in Art and Technology. New York: E. P. Dutton.

Lehrer, J. (2010). The Truth Wears Off. The New Yorker, Dec 13, 2010.

Pask, G. (1960). The Natural History of Networks, in Self-Organizing Systems: Proceedings of an International Conference, 5 and 6 May, M. C. Yovits and S. Cameron, eds. New York: Pergamon Press.

Pearce, C., Diamond, S., & Beam, M. (2003). BRIDGES I: Interdisciplinary Collaboration as Practice. Leonardo, 36(2), 123–128.

Steinheider, B., & Legrady, G. (2004). Interdisciplinary Collaboration in Digital Media Arts: A Psychological Perspective on the Production Process. Leonardo, 37(4), 315–321.

Ex-Scribing the Choreographic Mind—Dance & Neuroscience in Collaboration

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Abstract

Today, one of the most compelling conversations in trans-disciplinary engagement is the exchange between dance and neuroscience. Over the last decade, dancers and neuroscientists have come together to create live artscience laboratories in which to explore the processes underlying "choreographic cognition" and the embodied mind. Whether creating, performing and viewing dance, complex multi-modal physical and mental processes emerge indicative of high levels of creative thinking. Cognitive processes generated in dance making have potential benefits that stretch beyond aesthetic aims. Such benefits are tangible and extend into many different sectors of society: humanitarian, sociocultural, scientific and medical. The last decade fostered a number of formal dance-science exchanges and projects, with significant outcomes -- statistical and practical, aesthetic and scientific. Despite initial momentum, the field remains fragmented, with poor visibility. Creative clusters have not advanced theories or methods to evolve a focused discourse. While major funding sources have fertilized the ground beyond the pilot level in Europe, US funding sources have little grasp of the importance of this topic and its cross-disciplinary impact. Although dance affords extensive opportunities and benefits for the academy and for the welfare of society at large, projects face barriers to advancement, including clarity of a strategic vision, funding, access, and underdevelopment or resources, and substantive commitment and cohesion across disciplines. Several directions are needed to address these barriers. These include alliances forged within educational and cultural institutions to create environments that fully support cross-disciplinary creative research.

Introduction

Among the most important cultural movements of the 21st century, artscience collaborations lead in research and pedagogy (Edwards 2011). While these interdisciplinary currents carry enormous momentum in many sectors of art, science, and technology, dance is yet to become a recognized player, both within and outside of the academy. Between 2009 and 2012, the publication Leonardo (the International Society for the Arts, Sciences and Technology) put out an international call for submission of interdisciplinary curricula. Of the 70 courses received (largely from the U.S., both undergraduate and graduate), none involved dance (http://www.leonardo.info/index.htm and http://www.utdallas.edu/atec/cdash/).
Within the last decade, efforts have been made to document the degree to which dance has impacted positively on social capital and wide sectors of community cohesion (Guetzkow 2002; Mitchell, Innoue and Blumenthal 2002; Reid 2011). Results have shattered the perception that

dance is an esoteric, elite discipline devoted solely to 'art making.' As a distributed art form (Kirsh 2011), dance finds its (meta)physical axis in collaboration. Dance "excribes," meaning that through dance, processes unfold that make the implicit clear and explicit. Particularly relevant are the ways in which dancers physicalize thought. Dance is a prime example that cognition is for action. The kinds of problem generating and problem-solving in dance extend well beyond aesthetic values (deLahunta 2004). Further, today's dancers lead "hybrid lives" (Risner 2012: 185), sourcing from everywhere, far beyond the studio to find work and inspiration for research in unusual and uncustomary niches within society. The compendium of skills trained in dance impact on a range of sociocultural impact: material, psychopersonal, physiological and intellectual benefits (http://blog.worldprime.org/post/dance_research).

The processes of dance making are a unique form of embodied thinking and offer a unique window into our capacity for creativity and design. Today, cognitive neuroscience has chosen dance as its muse. Over the last decade, a rich dialogue has developed between neuroscientists and dancers. The dialogue addresses many issues around 'embodied cognition' in a movement-based art form that impact widely on both the intelligentsia and society at large.

The exchange is illuminating new ways of conceptualizing the interrelationship of thought and motor skill. Highly interactive forums and subsequent projects in applied research on choreography and neuroscience, new technologies and behavioral methodologies have evolved - computer languages and algorithms in software engineering, motion-capture analysis, and neuro-imaging, among them. New strategies and expertise are emerging with utilization of new materials and technologies in practice-led research. Leading the initiatives were key choreographers from Europe and Australia, including William Forsythe (Ballett Frankfurt), Wayne McGregor | Random Dance UK, and Shirley McKechnie and Catherine Stevens, University of Melbourne. Each has generated projects close to home, with research extending several centers for cognitive neuroscience in the US (David Kirsh, University of San Diego and Scott Grafton, University of California at Santa Cruz). These pilot initiatives were multi-directional, multi-dimensional and practice-led, engaging a wide range of information technology and digital media. Outcomes have been significant and are not reserved solely to creative products. Rather, these engagements affect our theoretical understanding of across a number of domains – cognitive and affective neuroscience, phenomenology, neuropsychology, and human movement science. Topics include (but are not limited to) embodiment, embodied cognition, motor control and motor learning, kinesthetic empathy, performance and motor skill optimization, and health/welfare of multiple populations.

Despite the enthusiasm and commitment of a growing body of international researchers, advancement of this nascent field remains stymied by various barriers (outlined below). These hinder the ease of engagement and execution of projects holding initial promise. Generally, the field remains fragmented. Little research in this area is being generated in the U.S., and few connections are being made with European and other world counterparts. Overall, the vision for the field-as-discourse needs to be clarified with better development and utilization of resources to create consilience and cohesion, both within and outside of the academy.

To work towards a truly viable, reliable and sustainable trans-disciplinary engagement, the following barriers need to be overcome:

1. Ecovalidity – Identifying and affording access to feasible sites (physical and virtual) where research can be dance-specific. This includes issues of type, size, location, accommodations and removal of excessive encumbrances that potentially alter or limit the legitimate dance environment; Yet, these environments ideally can incorporate the technology needed for investigation;
2. Feasibility - Developing models of engagement that allow for realistic time and scheduling to carry out research for all engaged parties and resources. This includes embedding in the research design the mutual feasibility of time and use of resources, as well as garnering realistic time-sharing for those project managers and researchers across the various disciplines;
3. Training - Establishing short-term cross-disciplinary training and sharing of expertise in both the vocabulary of respective disciplines, methodologies and technologies; Training will help avoid the "salad effect" of interdisciplinary projects which are only disciplinary in name;
4. Partnerships – Business and Sociocultural partnerships are needed to broaden the dialogue in ways that facilitate the democratic engagement of all participants. In this way, we build the trust and commitment to integration and fertilization of this unique knowledge culture, avoiding top-down and bottom-up hegemony;
5. Financial Support- While major funding sources have fertilized the ground beyond the pilot level in Europe, US funding sources have little grasp of the importance of this topic. Identifying a range of funding sources that, collectively, could share the financial burden in supporting research and in turn, reap benefits, philanthropically and financially;
6. Cost-Effectiveness - Prioritizing cost-effective technologies and management of material and non-material resources. This means developing a clear sense of the ratio of resources-to-product outcomes;
7. Precise/Concise Research - Bringing precision to the research questions raised so as to generate concrete and useful data that best supports the speculations and hypotheses. This requires building carefully on previous research designs and honing the new hypotheses to avoid impasse due to imitations within the technologies themselves.
8. Incentives. Further, collaborations should provide a substantive outline and methodology for artists to find pathways into fruitful engagement with scientists and vice versa.
9. Global Portals of Visibility – Many current interdisciplinary dance-neuroscience projects are operating as islands within campuses or as single artist-scientist project grants both within and outside of academia, with little to no knowledge, visibility, collaboration or sharing of resources
10. Future Legacy - Such data should in part be destined towards supporting the initial scientific evidence of the effectiveness of dance within artscience collaborations by way of dissemination and archiving (both digital and material);
11. Broadening the community of stakeholders, both academic and non-academic, will provide portals for shared ideas. They can be local, regional, national, or international specialists and databanks that provide grounding in theories, themes and practices. These communities will be committed to the passion of innovation while respecting the ethics of intellectual property and human resources;
12. Community Sustainability - Identifying the ways and means of generalizing results from these collaborations to multiple sectors of the lay public, including underprivileged,

disadvantaged, otherwise 'abled' populations and the wider sphere of lay public engagement.

Suggested Actions

The plan is to turn constraints into workable incentives. These elements include concrete utilization of human resources, tools, laboratories and other working environments, funding initiatives, education and training in cross-methodologies, and other conditions that would support the trans-disciplinary vision.

The following practical solutions to these barriers are based around 3 main initiatives:

Action 1 – Feasibility

Goal(s): Moving towards true trans-disciplinarity in which neither discipline becomes the other, but participates fully in the mutual engagement. This avoids the "Salad Effect" of Interdisciplinarity, in which two or more knowledge bodies agree to generate collaborative work, but whose results remain disparate, fragmented and lacking in epistemological or practical utility.

Generic Stakeholders – Universities (including deans to students), research funding sources, both inter- and extra-academic, professional societies and philanthropies, cultural industries, funding sources for the arts, community building and health and welfare.

Targeted Regoinal Stakeholders - A consortium of North Carolina Triangle and Piedmont universities - Interdisciplinary professors/teachers/students within the academy, particularly "translational" medical centers and organizations (e.g., Translational Science Centers of Wake Forest University Baptist Medical Center and Duke University Medical Center), or where interdisciplinarity has become part of the university vision (Duke University, Wake Forest University, Winston-Salem State University, Center for Design Innovation, Dance departments at Duke, Wake Forest University and North Carolina School of the Arts, and other university departments with which there are memoranda of understanding for research, such as University of Wyoming and Winston-Salem State University, Forsythe Technical College, and the Center for Design Innovation.

Suggested Actions

A. Establish focus group(s) for dance-cognitive science within the university consortium, generated, organized and implemented by students with the major purpose of brainstorming on relevant topics, locating, collating and exploiting resources. The focus groups will take several forms:

- First, as networking 'artscience cafes' to take place at Krankie's Café in Winston-Salem and Open Eye in Durham, NC. Here, professionals from the neuroscience and dance world in the associated academies in the larger North Carolina Triangle area will be invited to lead and participate in roundtable discussions.

- Offering Live webcasts and web-forums, which could also be connected to existing Dance-Science podcasting sites, such as DanceTech.Net.
- Formal research conference for dancers, scientists, other academicians and the lay public to provide the scope and benefits of choreographic cognition. The conference will highlight current examples of research dance as a live laboratory where dance making has been explored through digital technologies.

B. Pursue Intra- and extra-mural grants to support sustain initial educational seminars, research training, and interdisciplinary courses; Further, identify funding sources that would provide initial seed money for pilot research, and research training, substantive applied dance-science projects, and provide adequate media publicity; access to related educational seminars and conferences; and Recruiting and offering stipends to a cadre of graduate/undergraduate and community workers to help with mechanics of implementing projects as they materialize.

Potential Stakeholders:
These funding sources will include Translational Science Center- and other intra-mural grant opportunities, the Dana Foundation, insurance companies such as MetLife (those with a track record for funding dance-science initiatives), and arts foundations such as the Mary Biddle Duke Semans foundation.

Action 2 – Visibility

Goal(s) – Promote the visibility of the groundswell of work from Action 1 in order to reinforce local, regional, national, and global sustainability; Join forces with other networks that already are spearheading initiatives in this area.

Suggested Actions –

A. Initiate and manage an interactive website (including weblog) that has several tiers – regional, national and international;
B. Ground Level Networking and Publicity;
C. Organize local versions of TED;
D. Search out, contribute to, and participate regularly in, dance/science websites that already routinely provide podcasts and other interactive forums – chiefly, Dance-Tech.Net http://www.dance-tech.net/

Targeted Stakeholders:

University digital media laboratories within the consortium, with student/faculty support for building dance-cognitive neuroscience networks – Sourcing for social networking sites and other media that would offer platforms for visibility. Examples include:

Action 2 – Measurable Impact

Goal(s) - Provide material evidence of success of liaisons and collaborations; Define and substantiate the basis for success of liaisons and collaborations, as well as the mutual benefit mutual benefit of research; Move towards discourse.

A. Community engagement - Interactive seminars with artists, scientists and lay public to find niches outside of choreography that would benefit by dancers' physicalized form of cognition (examples)

    a. Business/Community Partnerships (e.g., of topics: Problem-Solving in Business Through Dance; Improving Learning through Training Attention – High School; Dance and Health; Memory and Movement in Aging; Dancing with Challenges (Parkinson Disease);

    b. Bring together choreographers and dancers, cognitive scientists, neuroscientists, and other academicians, scientists, and those in digital media and other technologies, for short, intensive, outcomes-based workshop series. The first workshop would address the needs specified above and emphasize strategizing to solve the problems. Outcomes would be targeted towards the feasibility and realization of select projects to be implemented within a 1-year period.

B. Organize and implement outcomes-based interdisciplinary courses for under/graduate students. Courses would be designed to help students gain fluency in areas of intersection between disciplines, breaking through initial conceptual prejudices about their differences. These courses would be offered as single electives or as part of cross-campus visions for artscience trans-disciplinarity;

    a. Developing, honing and validating tools and methodologies through piloting research and providing structured feedback and evaluation;

    b. Build a student-faculty consortium of researchers dedicated to short, succinct, time-limited, measurable pilot research on dance and cognition;

    c. Transmission and dissemination of results – both scholarly and practical – through formal and informal publications, documentaries, web submissions, conference presentations, sustainable community initiatives, etc.

Generic Stakeholders: The consortium of universities and their extended network with national and international universities, dance/dance science organizations, neuroscience and cognitive science organizations, cultural industries and museums, private sector investors and community partners, publishers and digital media industries.

Targeted Stakeholders –

Examples of University-based Centers
Center for Creative Entrepreneurship, Wake Forest University
HASTAC the Humanities, Arts, Science, and Technology Advanced Collaboratory at Duke University

Examples of Arts organizations -
American Dance Festival, Durham, NC
Contact Quarterly, a Journal for Moving Ideas
National Dance Education Organization
International Association of Dance Medicine and Science
The Mary Duke Biddle Foundation

Examples of funders supporting interdisciplinary arts-science initiatives
The Wallace Foundation
The Dana Foundation
Pew Charitable Trust
National Endowment for the Humanities

Examples of Community Partners
John Hope Franklin Institute
Chamber of Commerce
Local Art Museums, such as SECCA (Winston-Salem) and Nasher Museum (Durham)
Mayor and other key political figures

Summary

The waters already are stirring in small eddies within a number of universities across the North Carolina Triangle and Piedmont regions of the State of North Carolina. It is only a matter of organizing our efforts with passion, vision, and rigor in elaborating outcome based efforts. To my mind, university students can play a significant role in jockeying a fleeting topic into a discourse of substance.

References

Burns, S. Mapping Dance: Entrepreneurship and Professional Practice in Dance Higher Education. Lancaster, UK: Palatine Higher Education Academy, 2007.

DeLahunta, S. Separate Spaces: Some Cognitive Dimensions of Movement. Diffusion online journal. http://diffusion.org.uk/species_of_spaces/D_SOS_Delahunta_A4.pdf, accessed November 2011.

Edwards, D. (2011). Artscience: Creativity in the Post-Google Generation. Cambridge, MA: Harvard University Press, 2011.

Mitchell, W. J., Inouye, A.S., Blumenthal, M.S. Beyond Productivity: Information, Technology, Innovation, and Creativity. Washington, D. C.: National Academies Press, 2003.

Moran, J. Interdisciplinarity: The New Critical Idiom. 2nd. ed. London and New York: Routledge, 2010.

Guertzkow, J. How the arts impact communities: An introduction to the literature on arts impact studies, Taking the Measure of Culture Conference July 7-8, Princeton University, Princeton, N.J., 2002.

Reid, T. Art-Making and the Arts in Research Universities. 4-6 March 2011. Ann Arbor, MI: 2012. Prhtt//arts-u.org/wp-content/uploads/2012/03/ArtsEngine-National-Strategic-Task-Forces-Interim-Report-March-2012.pdf>.

Risner, D. (2012). "Hybrid lives of teaching and artistry: A study of teaching artists in dance in the USA", Research in Dance Education 13, 2, pp. 175-193.

Transdisciplinarity: Challenges, Approaches and Opportunities at the Cusp of History

http://wp.me/P2oVig-hE

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Until relatively recently science, engineering, art and design each had their own history. Increasingly they are becoming to be understood as components in the broad sweep of the production of knowledge for the good of humankind and the supporting environment. The most convincing evidence of this is in the shift in concern for the immediate and medium-term to the long-term sustainability of the earth as a nurturing environment e.g. approaches to climate change, water resources, holistic science, the socio-political and economic, as a global problem. The recognition of the interrelation and interdependence of hitherto discrete histories as important calls for new modes of interaction that are more than opportunist, convenient or problem-driven. This calls for more strategic approaches to transdisciplinarity as the organizing principle for research collaboration.

Survey concerns

In the last couple of decades voiced discussion around the new topic of transdisciplinarity has led to a growing awareness and application in the practice of more traditional interdisciplinary frameworks. Spearheaded by Helga Nowotny (2008, 2006, 1997; Nowotny *et al.* 2003) and Michael Gibbons *et al.* (1994) with a social science focus and by Basarab Niculescu (Camus and Niculescu 1997, Freitas et al. 1994, Niculescu 2008, 2002) with a science and humanities focus, the increasing literature on theoretical approaches and methodological reflections,
[1] shows transdisciplinarity to be more than a fashionable turn and is strongly supported by concrete actions and requirements in current research frameworks.

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1 A long and sustained engagement is evident in the theoretical physicist and philosopher Basarab Nicolescu's work and networks (CIRET) of transdisciplinarity, which departed from a scientific context bridging to Humanities concerns, with special interest in philosophicalreligious perspectives. Building on seeding events (OECD colloquium Nice 1970; UNESCO Colloquium of Venice 1986 leading to the Venice declaration), Nicolescu has spearheaded a theoretical, discursive engagement with transdisciplinarity and in 1987 founded the International Center for Transdisciplinary Research and Studies (CIRET). The social scientist Helga Nowotny, president of the European Research Council, together with a team of collaborators, a.o. Michael Gibbons, have been leading another core strand in the debate, which emphasises the production of 'socially robust knowledge' and is particularly concerned with the bridging between science and society geared toward a problem-oriented, applied modality. Another strong vector in the debate is marked by the US-based Humanities scholar Julie Thompson Klein (2010, 2001) who has

The need for transdisciplinary strategies arises in recent years from the increasingly recognized complexity of contemporary problems, including the exponentially growing data- and information load in segmented fields and formats, the demand for a more inclusive engagement with all sectors and strata of society as well as a closer confrontation and need for integration of the multiplicity of perceived conceptions and models of reality. This need for larger overviews and shared engagements, so it has been argued, requires a robust foundation in disciplinary practices and innovative approaches to collaboration and knowledge production and exchanges in interdisciplinary frameworks. Therefore it can be stated that transdisciplinarity is by necessity informed by the complementary extensions of those methods, views, models and conceptions that the single disciplines in their canonical frameworks and specialisation, and their exchanges among disciplines through interdisciplinary engagement, provide. By the same token, no discipline is ever completely isolated and has to be understood always in relation to other knowledge practices. With the broader awareness of the term transdisciplinarity, however, there occurs a slack use of the term in the context of cross-disciplinary collaborations. It points to an urgent need to seek clarity and to unravel some of the inherent confusions of the meaning and value of transdisciplinarity of some of these interventions if the moment is not to be lost. Some of the most frequent conflations that have led to misunderstandings in the current trend in the usage of transdisciplinarity are:

* Common confusion of transdisciplinarity with cross- and multi-disciplinarity arising from a generalized and unreconstructed use of the term, particularly as articulated with reference to 'global problems' and 'global thinking'.[2]

* Exclusive application of transdisciplinarity to engagements with non-academic stakeholders as a remedy for the disconnection between knowledge production and societal problems, whereby the term 'discipline' loses its meaning and justification.[3]

* Transdisciplinary as mere 'gap-filler' between disciplinary activities and boundaries in order to bridge communication gaps between the traditionally defined disciplines.[4]

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been leading the debate around interdisciplinarity, which provides a core foundation for many aspects that have been informing the discussions around transdisciplinarity. Emerging smaller platforms include the td-net in Switzerland (with a strong leaning on Nowotny's work), and the THESIS convention in 2003 in Goettingen (Brand et al. 2003) to exchange experiences and approaches to transdisciplinarity across the sciences and humanities.
[2] One of the key problems addressed in the debates around disciplinarity has first of all been the demarcation between multi-, inter- and transdisciplinarity. Multi-disciplinarity is understood as an accumulative, juxtaposed multi-perspectival arrangement of disparate disciplines that are brought together around a shared topic or concern. Although the knowledge production results in an accumulative overview, there is, however, no transformational interaction or cross-fertilisation between the disciplines which retain the original identity of their elements and the existing structure of knowledge is not questioned. (See for example Niculescu 2008: 2; Klein 2010: 17) Interdisciplinarity implies the transfer of methods, skills, concepts or paradigms from one discipline to another, which can lead to longlasting transformations of disciplinary frameworks. (See Niculescu 2008: 2; Thompson Klein 2010: 19) Thompson Klein (2010: 18) indicates the shift from multi- to interdisciplinarity when "integration and interaction become proactive", referring to Lattuca's (2001: 81-3) notion of "linking issues and questions that are not specific to individual disciplines".
[3] As for example identified in the foreword to the Handbook of Transdisciplinary Research (edited by Hirsch Hadorn et al., 2008) or in the profile of the TD Network for Transdisciplinary Research in Switzerland (http://www.transdisciplinarity.ch/e/index.php), wherein transdisciplinarity is identified as catalyst to open scientific knowledge to sociological approaches, the broader public and societal concerns.

* Misunderstanding of transdisciplinarity as shared fundament of inquiry, as 'common ground' to facilitate knowledge exchange.[5]

In contrast to these rather loose and unreconstructed responses to transdisciplinarity, the more robust and critical debate has been developed recently; we see this as crucial in order to ensure that the opportunity of new approaches to knowledge acquisition and development are not squandered. It can be summarised that at the very minimum, transdisciplinary research exceeds a mere cooperation among disciplines identified as multi-disciplinarity (Newell 2000: 230) and exceeds interdisciplinary research in that it leads to the transformation of the very identity of disciplines by identifying new topics and concerns. Transdisciplinarity extends the scope, methods and perspectives of existing disciplines whilst at the same time respecting and using the existing disciplinary frameworks. Ideally, emerging new practices, methods, paradigms consequently lead to a re-evaluation of disciplinary tools and concerns through interactive reflection and knowledge exchange, which can lead to transformative long-term impact on the development of disciplinary practice. In this way transdisciplinarity is a complementary practice in addition to inter-, multi- and disciplinary practices.[6] Without aiming at replacing any of the existing disciplines, it rather draws significantly on their foundations and specialisms. It has been frequently pointed out that most researchers engaged with transdisciplinarity move between disciplinary, inter- and multi-disciplinary engagements and modalities. The window of opportunity to define transdisciplinarity (or even transdisciplinarities) with precision is limited and there is an immediate need for a mature understanding and synthesis of the existing approaches that often substantially differ in their focus and sometimes even in their key aims and methodological underpinnings.

Although heavily reliant on topic-led approaches, interdisciplinary research (understood as integrative knowledge practice and exchange among two or more disciplines) has become an established practice in academia and also in the strategic policies of the research councils' national and international funding regimes. However, more sophisticated strategies are required in order to facilitate and build future trajectories for world-class research in terms of scholarly quality and also in term of their inclusivity of integral, ethically viable and creatively innovative concerns that transcend cultural, economic, geographical and social boundaries.

Since 2010 the International Network for Transdisciplinary Research (INTR) led by Transtechnology Research, Plymouth University, has brought together eminent researchers to consider more precise and useable understandings of transdisciplinarity in response to the urgency of high-grade collaborations led by immediate and burgeoning needs. It has proceeded from an enquiry into the daily practices of research in the Arts, Humanities and Sciences by

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[4] See the abstract for A Vision of Transdisciplinarity. Laying Foundations for a World Knowledge Dialogue (edited by Frédéric Darbellay et al. 2008)
[5] The initial coinage of transdisciplinarity, building on Jean Piaget (1972) and Andre Lichnerowicz' contributions at the OECD conference, was conceived as a "common system of axioms" that transcends disciplinary boundaries through an "overarching synthesis" as a kind of universal interlanguage with view to the internal dynamics of science. (Thompson Klein 2010: 24) Since then the debate has moved on and currently understands transdisciplinarity as heterogeneous rather than homogenizing practice, which accepts and respects plurality and diversity. This includes a similar critical view on so-called "holistic" approaches that neglect heterogeneity.
[6] See also article 3 in *The Charter of Transdisciplinarity* (Freitas *et al.* 1994).

experts who habitually reflect on their processes of knowledge production. The intention of INTR is to develop a robust framework to think and practice transdisciplinarity in action (rather than as a meta-theory), which departs from an integrative model of engagement that accommodates difference, paradox and speculative research. **Proceeding from this we take the view that a key aim of transdisciplinarity is to facilitate emergent insight, knowledge and interaction that could not have been foreseen or designed in anticipation of a specific outcome or solution to a problem.**

The model of transdisciplinarity proposed here takes a modest approach, in which the emergence of a new or differently posed question, an unexpected facet of perspective or an entirely new question completely independent of the inquiry in process, are valued in their own right and not sidelined through the common problem-driven approaches that limit the inquiry through the pressures on short-term, or immediately economically or materially viable, outcomes. **It calls for the development of theoretical, conceptual and practice-oriented approaches to transdisciplinarity as both, a post-hoc analytical process for the qualitative synthesis of collaborative research in interdisciplinary frameworks, and as methodological framework to forge innovative approaches to research collaboration that is inquiry-driven and seeks to identify new topics and concerns.** In this way transdisciplinarity is sought to bridge disparate areas of discourse and research topics not merely by transcending or transgressing disciplinary boundaries around problem-driven inquiries, but by letting the inquiry in itself drive the methods, tools and theoretical formation in order to stimulate the identification of new concerns, insights and topics that emerge from this cross-fertilisation of rigorous and imaginative scholarly research.

An emphasis in this approach to transdisciplinarity lies on 'transformation' in the sense of the transformative potential of transdisciplinarity: in the recursive reflective impact on disciplinary practice, the dynamic interaction between researchers and objects of study that are conceived as integrative processes rather than disparate entities, the consequential flatter model that breaks down certain hierarchical power-structures of the dominant institutionalized frameworks, as well as in the contingencies that dynamically shape the original research question from which the inquiry departed. In this sense transdisciplinarity is not exclusively to be understood as an aspiration to move outside disciplinary frameworks, but can just as well be provoked by an involuntary confrontation with insights and concerns intruding into disciplinary practices which stimulates, or in cases forces, the redefinition of their established scopes, problems and methods. **We are standing at the cusp of history with the possibility of taking transdisciplinarity seriously and see it as an invitation to seize new opportunities to resolve existing and immanent roadblocks**.

Roadblocks:

Aside from imprecise use of the term, which contributes to a general skepticism, there are real roadblocks to transdisciplinarity that need to be addressed. These are:

1) Roadblock: Inflexibility of mobility beyond and between institutional frameworks. The increasing sentiment encouraging permeability between industry and universities has encouraged

interdisciplinarity but has paradoxically led to an increasingly conservative culture of provision that more closely matches the existing (rather than future) employment market.

Opportunity: Amidst the virtues of disciplinarity it is now widely recognized that important and contributory research topics and concerns have been obscured in the shadow of disciplinary silos. This is evident in the number of hybrid research fields that have become necessary to form coherent communities e.g. biochemistry, techno-science, astrophysics, computational neuroscience, media-anthropology, visual culture, digital humanities, technology and culture, philosophy of science, anthropology of mind, etc. Transdisciplinarity offers the opportunity to maintain the virtues of the disciplines whilst exploring the shadows and avoiding the establishment of new hybrid disciplines which repeat the dynamics of the silos.

Proposed Action: Universities should consider themselves less as bastions of established bodies of knowledge and more as enablers with an emphasis on networks and collaborations and a locus for criteria in relation to methodological practices.

Stakeholders: Universities, research funding councils, professional societies, academic journals, publishers, philanthropic organisations, museums, archives, cultural industries, cultural funding organizations.

2) Roadblock: National funding for university research recognizes the virtues of transdisciplinarity/interdisciplinarity and multi-disciplinarity but still depends upon evaluation processes that rely on established fiats of experts in disciplines not necessarily fluent in approaches beyond their area of specialism.

Opportunity: The increasing focus on transparency and knowledge exchange as a consequence of the naturalization of multi-disciplinary research (i.e. the google scholar, crowd-sourcing and participatory archiving) is being met by equally radical approaches to publishing platforms. This follows a trend in the Arts and Humanities to focus more on impact, which has had the effect of closing the gap between the university and the public.

Proposed Action: If funding regimes wish to pay more than lip-service to transdisciplinarity they will need to consider radical changes to their review processes in order to include equal weighting for transdisciplinarity. For this they may need to consider the value of the network beyond its immediate results and raise the threshold of risk in funding research.

Stakeholders: Research funding councils, professional societies, governments, philanthropic organizations, cultural industries, cultural funding organizations.

3) Roadblock: Criteria for existing career and tenure tracks in research are informed by standards and expectations established by professional societies. Individual career tracks in transdisciplinarity are niche pathways in the social sciences and the arts and at best an excursion from the mainstream in the sciences. The ambitions of the market with its short- to medium-term risk are more comfortable with discrete disciplines with substantial long-term track-records of research return. As to the funding structures of the cultural industries, cultural foundations and ministries, bureaucracy or rigid organization of a museum or archive with its restricted review

processes often inhibit the acquisition and dissemination of new knowledge whilst at the same time marginalizing the appraisal of 'old' knowledge.

Opportunity: Universities and archives are no longer unchallenged gateways to acquired knowledge as a consequence they are reexamining their constituency and function. This provides new opportunities/challenges for rethinking the role of the University (and the archives/museums) in relation to permeable national boundaries, mass transport, electronic networks, linguistic dominance of English, providing new opportunities/challenges for exchange and comprehension.

Proposed Action: There should be investment in research network developments that regard transdisciplinarity as a pathway to new topics and concerns, liberating research questions currently locked within high-grade research in traditional silos. Hybrid public/private speculative funding of research and development should be encouraged.

Stakeholders: Universities, professional societies, academic journals, publishers, philanthropic organizations, private sector investors, museums, archives, cultural industries, cultural funding organizations, media industries.

4) Roadblock: There is a genuine and significant anxiety that transdisciplinarity (and even interdisciplinarity) will necessarily lead to a loss of focus and a consequent lack of rigour and authority. This roadblock is compounded by the inevitable difficulties of communications between specialists and competitive funding.

Opportunity: There is an unprecedented structural change in the production, dissemination and storage of knowledge brought about by a more democratic access to databases that need to be negotiated. Interdisciplinarity, multi-disciplinarity has facilitated comparative methodologies which have provided a framework for the management of large, disparate data-sets. Transdisciplinarity offers a more systematized way of management, synthesis and evaluation of knowledge.

Proposed Action: The full acknowledgement of transdisciplinarity's bottom-up spirit (both popular and data driven) should be regarded as both a methodological and social intervention. It gives voice to the intellectually disenfranchised who have a stake in the outcomes and as such mirrors many of the issues that have reshaped the Humanities (especially History, Art-History and Literature Studies) in the last three decades. Consequently it demands the vigilance and positive commitment that have been applied elsewhere when oversight and occlusion have become acknowledged.

Stakeholders: Universities, funding councils, professional societies, academic journals, publishers, philanthropic organizations, cultural organizations and social policy makers

5) Roadblock: An increasing fashionable over-usage frequently blurs the distinctions between multi-, inter- and transdisciplinarity and works at the disadvantage of, if not damaging to, those who rigorously engage with the conceptualisation and application of a new set of practices across disciplines that emerges from ongoing and current innovative research investigations.

Opportunity: In this regard Julie Thompson Klein (2010: 24-26) speaks of "trendlines" of transdisciplinarity with approaches that in some cases are thinning out to rather loose applications. There is now serious attention to the topic and high-grade research and initiatives (among others Niculescu's CIRET, Nowotny *et al.*, INTR).

Proposed Action: There should be investment in soliciting meta-approaches to transdisciplinarity informed by grounded research in the Sciences, Humanities and Arts. Greater attention to dealing with the issues exposed by transdiciplinarity (if not in the concept itself) should be explored openly.

Stakeholders: Universities, funding councils, professional societies, philanthropic organizations, cultural organizations and social policy makers, museums, archives, cultural funding organizations.

6) Roadblocks: The requirements that transdisciplinarity places on a researcher can be as demanding as, for example, extending the research period in order to acquire a new language or competence. The necessary delays and deferments that this entails currently can be perceived to make transdisciplinary research more expensive. As a consequence this loads the dice in favour of the disciplinary *status quo*.

Opportunity: A significant change in first world demographics (longevity, distribution, mobility and kinship) provides new opportunities/challenges for knowledge exchange, storage and transfer as human capital. In particular the educational experience should include 'life-long learning' which can accommodate significant intellectual growth and transformation.

Proposed Action: To learn from the contingencies and expediencies currently applied in dealing with these problems and responses to new forms of funding and dissemination and research practices in the Humanities (digital Humanities) and to see them as a mode of inquiry for example to conceptualize the big data problem as one coextensive with work in the Humanities on representation and archiving rather than as an exclusive domain of datasets.

Stakeholders: Universities, funding councils, professional societies, academic journals, publishers, philanthropic organizations, cultural organizations and social policy makers, museums, archives, cultural funding organizations, media and cultural industries.

References:

Brand, F., Schaller, F. and Voelker, H. (eds.) 2003. 'Inter- und Transdisziplinarität erlebt. Impressionen von der Göttinger Arbeitstagung »Transdisziplinarität«', *These*, 52, pp. 27-32.
Camus, Michael and Nicolescu, Basarab (eds.) 1997. "Declaration of Locarno". As part of: *Declaration and Recommendations of the International Congress "Which University for Tomorrow?" Towards a Transdisciplinary Evolution of the University.* Locarno,

Switzerland, April 30-May 2. In: Nicolescu, Basarab (ed.). 2008. Transdisciplinarity: Theory and Practice. Cresskill, NJ: Hampton Press, pp. 268-269.

Darbellay, F., Cockell, M., Billotte, J. and Waldvogel, F. (eds.) 2008. *A Vision of Transdisciplinarity. Laying Foundations for a World Knowledge Dialogue*. Lausanne, Switzerland: Swiss Federal Institute of Technology Press & CPC Press.

Freitas, Lima de, Morin, Edgar and Nicolescu, Basarab (eds.). 1994. *Charter of Transdisciplinarity*. Adopted at the First World Congress of Trandisciplinarity, Convento da Arrábida, Portugal, November 2-6. In: Nicolescu, Basarab (ed.). 2008. Transdisciplinarity: Theory and Practice. Cresskill, NJ: Hampton Press, pp. 261-265. Online at http://basarab.nicolescu.perso.sfr.fr/ciret/english/charten.htm (accessed 15 September 2012).

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M. (eds.) 1994. *The New Production of Knowledge. The Dynamics of Science and Research in Contemporary Societies*. London/Thousand Oaks/New Delhi: Sage.

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher, W., Joye, D., Pohl, C.,

Wiesmann, U., and Zemp, E. (eds.) 2008. *Handbook of Transdisciplinary Research*. Springer.

Lattuca, Lisa. 2001. *Creating Interdisciplinarity: Interdisciplinary Research and Teaching Among College and University Faculty*. Nashville: Vanderbilt University Press.

Newell, William H. 2000. How Do We Research and Evaluate Transdisciplinarity? In: *Transdisciplinarity: Recreating Integrated Knowledge*, edited by Margaret A. Somerville and David J. Rapport. Oxford: EOLSS Publishers, pp. 230-231.

Nicolescu, Basarab. 2008. *Transdisciplinarity: Theory and Practice*. Hampton Press.

___2002. *Manifesto of Transdisciplinarity*. Albany: State University of New York Press.

Nowotny, Helga. 2008. *Insatiable Curiosity. Innovation in a Fragile Future*. (transl. Mitch Cohen). Cambridge, Massachusetts; London, England: The MIT Press.

___ 2006. The Potential of Transdisciplinarity. In *Interdisciplines*, online at: www.interdisciplines.org/medias/confs/archives/archive_3.pdf pp. 48-53.

___1997. 'Transdisziplinäre Wissensproduktion – eine Antwort auf die Wissensexplosion?', in

Stadler, F. (ed.) *Wissenschaft als Kultur. Österreichs Beitrag zur Moderne*. Wien/New York: Springer, pp. 177-195.

Nowotny, H., Scott, P. and Gibbons, M. 2003. Introduction, *'Mode 2' Revisited: The New Production of Knowledge, Minerva*, 41, pp. 179–194.

___2001. *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press.

Piaget, Jean. 1972. 'The Epistemology of Interdisciplinary Relationships', in Apostel *et al*. (eds.) *Interdisciplinarity. Problems of Teaching and Research in Universities*. Paris: OECD, pp. 127- 139.

Thompson Klein, Julie. 2010. A Taxonomy of Interdisciplinarity. In: Frodeman, Robert,

Thompson Klein, Julie and Mitcham, Carl (eds.) 2010. *The Oxford Handbook of Interdisciplinarity*. Oxford: Oxford University Press, pp. 15-30.

Thompson Klein, Julie, *et al.* (eds.) 2001. *Transdisciplinarity: Joint Problem Solving among Science, Technology and Society*. Basel, Boston, Berlin: Birkhaeuser Verlag.

Creative Artificially-Intelligent Agents for the Arts:
An Interdisciplinary Science-and-Arts Approach

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Artificial Intelligence (AI) has made impressive progress since its start in 1956. It now influences our daily lives, as AI systems are an integral part of consumer technology today, from SIRI to automobiles to Semantic Web. However, while AI systems can be very successful if they are precisely told what to do (e.g., perform a parallel parking task, play chess), they are usually useless if the objectives are not clearly spelled out. They can learn along a precisely given trajectory (e.g., to learn to understand spoken text or compose an instrumental music piece in the tradition of JS Bach), but they don't break rules to produce something more exciting. Deep Blue can play chess, but if you present it with a game implemented on a chess board, it will be lost. In short, machines are simply not very creative. The idea of this white paper is to form an intellectual think tank to overcome existing roadblocks and investigate alternative strategies in AI. Among the items that will be discussed is the implementation of design oriented processes for AI systems. Artists and designers often work on a less hypothesisor goal-driven approach as compared to scientists and engineers; they pursue an open-ended, purely experimental approach instead, where the outcome of each phase informs the next one, not necessarily having a fixed goal in mind. Along with this approach, there is a need for better AI evaluation systems that can judge the outcome more freely than just examining the results along an externally given set of rules. Using the experience of artists with the abstract, can we make agents more creative by allowing them to be continuously evaluate what they accomplish? How can we create AI systems that can develop and evaluate their own concepts? Part of this discussion will include the creation of a network for more complex AI systems that simulate several areas of the brain, or the abstract AI equivalent, simultaneously, by using a meta-concept to connect existing AI modules using a UDP protocol in a computer-cluster network. Another central aspect are systems that can draw on different algorithms to perform a task, making the selection part of the creative process. Along the same lines, we can look into web data-mining methods that allow these machines to receive information beyond what is given to them by the experimenter.

Action Items

1) Complex Systems with Modular Architecture and Interchangeable Data Format

Roadblock: A lot of specialized software exists to simulate certain aspects of intelligence from computational auditory scene analysis algorithms to logic prover. In general, it is still very

difficult to combine these specialized systems to complex systems simulating multiple parts of the central nervous system.

Opportunity: Enable a dialog to find better ways to standardize communication protocols between different systems and to port algorithms to a unified platform for creative intelligent systems

Proposed Action: conference or symposium to start dialogue

Stakeholders: university-based groups, gaming and entertainment industry

2) Agents that can handle abstract media and techniques

Roadblock: In engineering and science related disciplines a common approach is to copy the human body in both form and functionality. Honda's Asimo robot and Kaist's Hubo are good examples for this approach. Sometimes abstract solutions provide a better functionality, for example robots from children and science fiction movies are often more sociable, but artists and designers often lack the technical expertise of engineers

Opportunity: bring both groups together to build on each others' strength to build highly functional, powerful but abstract systems.

Proposed Action: conference or symposium to start dialogue

Stakeholders: university-based groups, gaming and entertainment industry

3) Need of creative synthetic characters that can develop new concepts

Roadblock: Over the last 40 years we have develop artificially intelligent agents that can produce creative work within a given context (e.g., compose music in the style of J.S. Bach), but system that go beyond this and develop their own concepts (e.g., a new composition style) do not exist yet (at least not in the sense that they can reflect and justify their actions).

Opportunity: bring together transdisciplinary groups of artists, psychologists, and engineers to elicit how humans complete these tasks and find ways to implement this knowledge to artificially intelligent systems.

Proposed Action: conference or symposium to start dialogue

Stakeholders: university-based groups, gaming and entertainment industry

Using 'Processing' as a Stimulus for Producing STEAM

http://wp.me/P2oVig-hL

Coordinator: Ron Brown, Computational Artist/Educator/Programmer

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November 8, 2012

The Challenge and the Opportunity

Sir Ken Robinson [1][2] has called for a paradigm shift in our educational system away from the use of standardized testing and behavior modification drugs on our youth to one of enquiry and creativity in the arts and sciences. I think a great opportunity exists today to achieve many of the goals he advocates utilizing tools from the open-source community, in particular, a computer programming language called 'Processing' [3]. I believe Processing can be used as a stimulus for merging the worlds of art, math, science and technology to meet the challenge of changing paradigms.

Processing

Processing is an open-source (FREE!) programming language developed at MIT by two graduate students (Ben Fry and Casey Reas) that is targeted for visual artists who would like to utilize digital media in their endeavors but who lack computer programming skills. It has become so popular that several circuit board manufactures have developed boards that can use Processing to obtain sensory data and/or to control motors (think 'robots') and other devices. In addition, Processing can be used to obtain data from the Kinect 3D camera (Xbox) for visual explorers to investigate the realm of 3D interactive media.

Course

During the spring of 2012 I had the opportunity to teach a 'Programming with Processing' course at a small independent Buddhist high school [4] in Ottsville, PA. The course met twice a week for twenty weeks where each session was one hour twenty minutes long. The students varied widely in academic skills and backgrounds and came from several different school districts but all stated they were glad they took the course. One student stated he had known nothing about programming prior to taking the course but is now considering computer programming as a career. The only prerequisite for taking the course was the desire to learn a computer language – no other strings were attached. On June 22, 2012 I was one of several presenters at a STEM to STEAM conference held in Baltimore, MD, where I talked about the course and showed images created by the students [5]. Some of my own artistic explorations using Processing can be found at [6].

Potential Participants

I think a course using Processing to create images would be greatly appreciated by 'gifted' students, by students who are comtemplating dropping out of school because they are bored, students who may have gotten in trouble with the law, other 'high-risk' students and students in the 'general' population. The growing 'home school' movement should not be exempt from the opportunity of utilizing Processing in its curriculum either. Another targeted population that should not be excluded is that of teachers who would like to explore Processing themselves and learn how it can be used in their own classrooms to produce some STEAM. I feel strongly that the only prerequisite for any student should be the desire to learn a computer language. Let the student have the opportunity to fail in a 'safe' environment and learn from his/her mistakes. Computer programming is an unforgiving endeavor and attention-to-detail is a must that is soon learned. But, it's FUN!

On a more grandiose scale, curricula based on Processing could be developed for interested school systems starting at the sixth grade level or below and extending through the senior high school level. Estonia (birthplace of Skype) has implemented a plan to introduce computer programming to students beginning at age 6 [7].

Suggested Actions

Suggested Action #1: Finding 'Qualified' Programming Instructors

Barrier: Too few secondary teachers have any substantial computer programming experience – no matter what subject(s) they are 'certified' to teach. Unfortunately, there are many experienced programmers who know different computer languages but they are not allowed to teach because they do not have a teaching 'certificate' to do so as required by the educational establishment.

Stake Holders: School administrators, federal and/or state legislators, Departments of Education, teachers who want to make their classes more exciting, teachers' unions, unemployed/retired computer programmers

Suggested Actions: During the last decade, many software projects were outsourced to developing countries, leaving many American computer programmers jobless. A large number of these former computer programmers could be recruited and learn Processing in a relatively short period of time – compared with someone with no previous programming experience – perhaps within one month or less. With appropriate incentives, these 'new' senior recruits could teach either younger teachers or teachers-to-be enrolled in colleges/universities/community colleges or teach within the secondary-school system itself. Educational instutions should be encouraged to offer computer programming courses in their STEM or STEM to STEAM programs.

Opportunities: Employing qualified senior citizens would be a win-win situation for those invited back to the workforce and for those who would benefit from their expertise. Current teachers will have the opportunity to learn skills they may have never experienced before.

Suggested Action #2: Eliminating standardized testing for STEM to STEAM endeavors.

Barrier: Standardized testing is so engrained in the educational psyche/system and is overly encouraged by testing services as well as textbook publishers and the Federal Government implementing laws such as 'No Child Left Behind'. Standardized testing does not measure/encourage 'creativity'. As Sir Ken Robinson has stated, 'creativity' is destroyed as a student progresses through the educational system.

Stake Holders: School administrators, federal and/or state legislators, Departments of Education, teachers' unions, textbook publishers, testing services, art galleries

Suggested Actions: The only prerequisite for taking any computer programming course should be the desire to learn computer programming. A student's 'grade' should not be based on any post-course test or battery of tests given throughout the course. Rather, a student's grade should be based on the student's completion of programs (called sketches in Processing) and/or one's effort in completing the assigned tasks (Example: one of my students had severe dyslexia but I have never seen anyone work/concentrate so hard to complete a sketch.). One goal of the course could be to show the students' art in an art gallery setting and use the proceeds of any sales to support STEM to STEAM projects.

Opportunities: Implementing a 'testless' course utililzing up-to-date technology would be an ideal case for one of Sir Ken Robinson's desires which is to eliminate standardized testing.

Suggested Action #3: Developing curricula spanning multiple grade levels.

Barrier: Knowledgeable curriculum developers may be few and far between. A related barrier is preventing the unintended consequence of institutionalizing computer programming as a mandatory subject. Just as Processing is 'open'-source, school administrators should be 'open'-minded when implementing such courses/programs. The only prerequisite should be the desire to learn a programming language.

Stake Holders: School administrators, teachers, curriculum developers, private grant foundations, Educational Departments

Suggested Actions: Instead of local districts being burdened with the task of developing their own curricula districts should utilize world resources. Agencies such as NASA and the NSF, along with private donor organizations, should take active roles in such development efforts.

Teaching Processing would allow those interested in robotics to learn the mechanics of motion/control using Arduino hardware. Those interested in the performing arts could expand their horizons by using Processing to interface with the Kinect camera for interactive performance utilizing music and/or other devices. To minimize costs, the use of textbooks should be minimized or possibly eliminated – internet resources are abundant and should be maximized to the fullest extent. Programs such as those being implemented in Estonia should be followed closely.

Opportunities: Networking with other like-minded individuals/organizations around the world would be very rewarding for all involved.

Suggested Action #4: Providing each student with access to a computer for programming.

Barrier: Many school systems do not have the monetary resources to provide individual access to a computer for programing purposes.

Stake Holders: School administrators, private grant foundations, parents, community groups, corporations

Suggested Actions: Many students have their own computers that have plenty of 'computer power' for programming purposes. Students who have their own computers should be encouraged to use them. Also, many companies upgrade their computer networks periodically and dispose of their computers en mass – companies should be encouraged to donate their used computers to their local school districts. Computers used for programming need not be connected to the internet permanently so the need for more net-working expertise would be minimal. Grants from private foundations should be sought.

Opportunities: Community involvement of parents, students, administrators, teachers and businesses would create a more caring community.

Suggested Action #5: Evaluating the proposed Processing course/curriculum.

Barrier: Many school systems do not have the monetary resources to monitor/evaluate the success/failure of new educational programs.

Stake Holders: School administrators, state Education Departments, program evaluators, graduate students, teachers' unions, parents, students

Suggested Actions: One or more graduate students in the near vacinity could be encouraged to write a thesis evaluting the proposed course/program and/or the State's Department of Education would have the task of evaluting the program.

Opportunities: Knowing the outcome of early courses/programs would lead to improved courses/programs that would grow as technology changes.

Suggested Action #6: Providing resources to small independent schools and the home schooling movement.

Barrier: Small independent schools lack funds for such 'esoteric' courses/programs and would only be able to offer one if one of their limited staff had the skills/knowledge to teach the course. When I asked about teaching another 'Programming with Processing' course the following semester I was told that there was no funding available. I am quite sure that, had the school had adequate funds, I would have been able to offer the course again.

Stake Holders: Independent schools, parents, students, teachers, private grant foundations, corporations

Suggested Actions: Parents who send their children to private/independent schools, or, those that choose to home school, still pay federal and state taxes targeted toward educational programs – there is no reason their child should not have the same opportunity to share in STEM to STEAM endeavors as those attending public schools. Because of the current economic downturn it would be worthwhile for all school environments to share their expertise/resources with others.

Opportunities: Acts of kindness lead to acts of kindness. And, it's the right thing to do for our children and our future.

References

[1] Sir Ken Robinson's 12-minute summary: www.youtube.com/watch?v=zDZFcDGpL4U
[2] Sir Ken Robinson's 55-minute address: www.thersa.org/events/video/archive/sir-ken-robinson
[3] Processing website: http://processing.org
[4] Tinicum Art and Science High School: www.tinicumartandscience.org
[5] Innovate Our World Conference: www.innovateourworld.org/conference.htm
[6] My own artistic explorations using Processing: http://ron-brown.artistwebsites.com
[7] Estonia implements programming at age 6: http://gigaom.com/europe/estonias-plan-to-get-6-year-   olds-coding-is-a-stroke-of-genius/

Processing Books

Algorithms for Visual Design Using the Processing Language by Kostas Terzidis (Wiley Publishing, 2009)
Making Things See – 3D Vision with Kinect, Processing, Arduino, and Makerbot by Greg Borenstein (O'Reilly, 2012)
Processing – A Programming Handbook for Visual Designers and Artists by Casey Reas and Ben Fry (The MIT Press, 2007)
Processing – Creative Coding and Computational Art by Ira Greenberg (friendsofED, an Apress Co., 2007)
Processing for Visual Artists – How to Create Expressive Images and Interactive Art by Andrew Glassner (A.K. Peters, Ltd., 2010)

A New Ecology of Learning: Ecological Systems as Pedagogical Models

http://wp.me/P2oVig-kH

Coordinator: Pavel Cenkl, Sterling College – November 2012

Abstract

This white paper introduces a new ecology of learning and innovative connections between ecological and a humanities curriculum. Drawing on points of intersection between experiential liberal arts education, digital humanities, biomimicry, and ecopsychology, this paper will engage instructors and administrators in course development strategies and in helping students plan their own learning by using a systems approach to curriculum design.

SUGGESTED ACTIONS

Ecological Learning and the Liberal Arts
Premise
An ecological model of thinking can provide a model for a more intentional and dynamic liberal arts pedagogy.

Actions
Academic Administrators should recognize that biological design processes can follow a model that spirals from (1) discovering natural models to (2) abstracting design principles to (3) brainstorming potential applications, (4) emulating nature's strategies and finally (5) evaluation. The process continually repeats itself as successive curricular iterations are discovered, employed, and assessed.

Faculty and administrators alike can embrace an ecological framework can underscore the resilient, decentralized, and distributed, and integrative pedagogy of a liberal arts curriculum, thereby empowering more intentional and organically developed student-centered learning experiences.

Digital Technologies and Ecological learning
Premise
Digital technologies can help institutions to develop more ecologically focused learning environments and curricula.

Actions

For Administrators: Technologies should help us redefine how we use learning spaces—both virtual and actual. Online tools should resonate with organic structure of information flow, and classes should be inherently embracing such flow of information and knowledge.

For Faculty and Administrators: Introduce technologies that enable real-time connection between student experience and classroom reflection and provide information and access that can

help classes become self-organizing and less hierarchical. The ecosystem has become as much a metaphor for collaborative technologies as it presents a framework within which to contemplate its development; however, as much as ecology may be an apt metaphor for digital community - in its dynamic development and organic integration of ideas in (often serendipitous) boundary objects, there continues to be a tension between the ubiquity of software and the reality of experience, a tension which is ignored by many.

Faculty, administrators, and students can recognize that getting one's hands dirty in the performance of literal, actual, meaningful work can be the scaffold for community, collaboration, and engagement that technology can potentially help facilitate.

Integrating Ecological Thinking
Premise
Ecological thinking can be integrated into both new and existing courses, units, and overall curriculum designs.

Actions
Academic Administrators and Department Chairs should champion a comprehensive revisioning of course offerings from the perspective of outcomes-based assessment to emphasize a systemic and integrative—rather than disciplinary and course-based—curriculum. They must similarly engage in meaningful revision of workload and workflow in order to achieve more robust support for the integrative student learning that is the core of liberal arts pedagogy.

Academic Administrators can integrate curricula of earth and biological science courses to foster a deeper understanding of the interrelationships of methods, products, projects, and initiatives across the different disciplines. Course can also be block scheduled in order to empower integrative learning communities.

Individual Faculty should use the flexibility within workload guidelines to explore further collaborative and cooperative teaching opportunities that empower students and faculty alike in integrative systems thinking. Truly organic development of curriculum necessitates a ground-up process that involves faculty and students in co-creation of integrative courses, coursework, and programs.

Science-Art Interactions in Asia With Particular Reference to India

http://wp.me/P2oVig-jz

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Introduction

"Life itself is a beautiful interaction between art and science. You cannot escape this reality no matter what you say or do!"

While North America, Europe and Australia are basking in the glory of new wave science-art collaborations and reaping all the benefits that these interactions are bringing, there are some parts of the world that are relatively untouched by these happenings! Asia, to which the Indian subcontinent belongs, remains almost immune to the developments happening around the world in this arena. With the exception of China, we find very few science-art projects in the region. In a coordinated study for this paper, an attempt has been made to (a) find the extent of science art interplays in Asia, (b) seek reasons for the little interest on science based art here and (c) explore ways to correct the situation.

Some interesting observations:

Science and technology are being used in Asian countries mostly as tools rather than as themes to create art [1,2,3]! Art is being used more frequently in schools as an educational aid to teach children Science in most of the countries here [4,5]. Art in the form of films and videos is also being used to propagate science knowledge among Asian communities [6]. Artists in the Asian countries where 'science' is being used as a theme (eg., Ecology) to create art are approaching it from a socio-economic point of view rather than dealing it as a pure subject [7,8,9]. Majority of the people who are venturing into the arena of science-art in Asia are from the field of science or artists who have scientific or technical backgrounds. Magazines and journals that are encouraging science-art and publishing articles on the subject also belong to the field of science and not art [10]!

Types of interactions noticed between science and art in Asia:
1. Creating art using Science and technology as tools(S&T assisted art) [11,12,13,14,15].
2. Creating art scientifically [16]. A few artists in the region are sensitive to the well-being of the environment and are using recycled or organic materials to create art. Some are also using eco-friendly printers, to have all their art pieces printed on recycled paper with soy-based ink [17,18,19].
3. Doing science-art (science illustrations- painting lab specimens and models in colours)[20].
4. Creating science based or inspired art (taking pure science themes and theories, connecting them to art and producing works based on them) [21,22] .
5. Scientific studies of the artistic processes [23].
6. Coming together of artists and scientists to solve some of the biggest technology development challenges in sectors such as health and the environment [24].
7. Approaching science by artists from a social point of view [25].

8. Using visual techniques like origami- paper art to teach science subjects [26].

Countries and the interactions happening in them:

In Asia, science-art interactions are mainly concentrated in China, Japan, South Korea, Singapore, Indonesia, India, UAE, Iraq and Israel. Interestingly these areas with healthy scientific backgrounds [27,28,29] are relatively high on the economic scales too in the region [30,31,32]. In other parts of Asia, except for instances of technology assisted art [33], there is no work based on pure science-art worth mentioning. As technology assisted art is ubiquitous in Asia like in the other parts of the world, I am not delving deep into the subject.

East Asia:
China: Although not as vivacious as the ones in the West, there is a vibrant activity in the Chinese science-art arena. Artists in China seem to have warmed up to the idea of science-art interactions and started working with enthusiasm to deal with projects based on the subject [34,35,36,37]. China is also conducting art-science symposia and international exhibitions regularly [38,39].TASML recently launched an International Artist Residence Program (TASML IRP) in collaboration with Institut Français, Goethe Institute (China) and Pro Helvetia which focuses on laboratory inspired artistic practice [40]. As another coordinator is discussing China's science-art scene, I am not going deep into the details of interactions.

According to some of my Chinese artist friends the reason for these thriving science-art collaborations in China is the importance given by the Communist Government there to promoting science. The results could be seen in all areas [41] including art. An enviable economic growth combined with big art market boom in China seems to be fueling good funding mechanisms too for the artists to experiment with new tools and themes. Another important contributing factor could be artists there are more open to experimentation with Science. There is a sort of rebellion and new art movements are taking roots without any resistance in China [42].

Hong Kong's close association with both Britain and China (a special administrative region of it) has a positive impact on its science-art sphere. A symposium was held in Hong Kong in March, 2012 during an art and science festival, titled "Art and Science Symposium – Conjunctions of Artistic and Scientific Processes" [43] Microwave International New Media Arts Festival, in partnership with the British Council, hosted a unique art-science lab exhibition 'Laboratory Life' by the leading UK arts agency Lighthouse recently at Hong Kong City Hall. Works by 21 international artists, scientists and doctors, which are an exploration of bioscience and the use of medical technology is the important feature of this show [44]. A show by the artist Yim Wai Wai under the categories of "Pseudo-science" and "Pseudo-myth" is worth mentioning [45].

Science art scene in Japan is similar to that of India-very little activity in the area of actual science based art and more importance is being given to tech-assisted art [46]. More over, according to some journalists, whatever science based art created there is being done in a state of confusion! [47,48]. A record of a hundred year old science-art pictures in Japan is catching the attention of the scientists in the region[49].

There is a single report of artists and scientists coming together in **Korea** [50].

South-East Asia:
Recently one university in **Singapore** has conducted residencies that dealt with science-art [51]. Science-art museum of Singapore exhibits science and tech assisted art [52]. Artists in this region are mostly dealing with sci-art from the socio-economic point of view [53,54,55].

Indonesia is the best example to quote in Asia where science and art are combining to help communities and societies. Honf foundation there works as a forum to bring artists and scientists together to solve some of Indonesia's biggest technology development challenges in sectors such as health and the environment [56].

South Asia:
The paintings of historical scientists in a **Pakistani** gallery are worth seeing [57].

In **India**, the interactions between art and science were very poor till recently but slowly picking up momentum now. Artists here are mainly dealing with technology assisted art. Apart from me-who deals with science-literature, science based art and science-art [58], Mr. Sukant saran, a physicist turned artist, too deals with the artistic side especially patterns of the scientific objects using digital art technology and photography [59]. Dr. Sharada Srinivasan, with the support of her institute (National Institute of Advanced Studies), experiments with dance and science interplays [60,61]. Mr. Sastry of Bangalore uses Origami paper-art to teach Math [26]. Prof. Promod Rai painted a few pictures of fungal spores, chromosomes and genes copying from text books (science-art) [20]. Mr. Basant Soni creates art using organic material [17]. Ms.Aditi Kulkarni 's background in Physics makes her experiment with digital and installation combinations. Construction of a site-specific installation that will employ kinetic sculpture, photography and moving images to create an immersive sensory experience is her specialization [62,63].

Viswa Bharati University(West Bengal) -- started by Rabindranath Tagore-- is about to start music with science course from next year [64].

Center for Cellular and Molecular Biology's (CCMB, Hyderabad) ex-director, Mr. PM Bhargava's interest in art made him invite artists to do works on his campus. They have a big collection of art works now [65]. They had an artist-in-residence programme too when Mr. Bhargava was the director of CCMB [66].But when you see the CCMB art work display you will notice that after the interactions with the scientists not one artist created works based on science on its campus! [67] When I tried to find out the reasons for the same, I drew a blank because both scientists and artists I contacted couldn't pin point them! The same situation is true for other encounters between artists and scientists in India. For example artists have been visiting Vikram Sarabhai space centre in Ahmedabad during art festivals organized there [68]. But these visits by artists to the science centers are not leading to any significant outcomes!

Srishti School of arts (Bangalore) says it too deals with science-art but after checking their work, you get the idea that they deal mostly with science and technology assisted art like media art rather than pure science art [69]. Their 'sci-art project' looks like a high school science

project rather than a science-art one [70]. One or two young artists in India are also trying to create science related art [71] but it is too insignificant to add here.

This aspect of science not inspiring the world of art in India is really startling. Because, the Central Government in India too gives top priority like the Chinese Government to promote Science education here. But still the results are not the same! The main reasons for the situation described above will be dealt with after mentioning about the interactions in other regions of Asia.

West Asia:
There seems to be an interesting interplay between science, art and literature in the West Asian region in the earlier centuries [72]. However, there is no strong evidence of this continuing into the present times as art and literature works based on science are very scarce. The tastes and the expectations in this part of Asia might have changed now. My Arabic artist friends analyzed the reasons for the same in this way: Artists in the West Asian region experiment with a variety of techniques and styles that have roots in their cultures irrespective of the current international trends. Recent rise in religious fundamentalism that gives more prominence to religion and culture based on it is one of the main causes for this decline in interest in science. Present day artists in West Asia really have no choice as Science as a subject has less prominence than other themes of art there. However, some rebellious young generation artists are trying to come out of the shadows of these fundamentalists and are experimenting with science. They already have a young, enthusiastic, US-returned **Iraqi**, Mr. Bilal Ghalib, who started some steam projects in the region [73]. We will have to wait and watch to know how much these youngsters will succeed. Two positive aspects that can be observed in this region are: (a) schools in this region - especially in UAE - are trying to keep old traditions of science-art interactions alive [74,75] (2) science-art work from socio-ecological view point is thriving here too [76]. Taking old junk accumulated over the years, and then turning it into sculptures using the engineering, design skills and imagination is one example.

Israel: The closeness between the US and Israel seems to have affected positively the science-art scene of Israel as it has a sound science-art interaction arena [77]. Some important examples: art obtained from sci- photos [78], science-art interactions in schools [79], hosting science-art exhibitions of artists from other areas of the world [80] and Israeli sci-artists participating in the shows in the US. An Israeli university is providing an MA course in Art Therapy [81].

Road blocks: "Identifying a problem is the first step to solving it"

In order to correct the situation of dismal performance of science-art interactions in this part of the world, first we have to identify the reasons that are responsible for it. Therefore, have a look at the picture of them I painted here….

1. Very few funding mechanisms: In continents like Europe, America and Australia there will be several funds, sponsorships, grants etc. to support art projects that cover significant number of artists. Therefore, artists there can experiment in any way they want because their monetary

needs will be taken care of by these funding mechanisms. In India and most parts of Asia there are very few funds that can't cover the needs of the art world here. And 'low priority' science-art projects have no chance of getting them at all! India's art institutions rely on a handful of very rich private donors and major foreign foundations for funding, or fall back on government grants [82]. The problems of arts funding, according to experts in major arts institutions in India, are threefold. First, there is a general lack of distinction between art and culture. Second, more effective and efficient institutions are needed to create a network of philanthropy. Third, there is a need to attract funding from a wider range of donors. Ministry of culture, Government of India, spends a paltry sum on art and culture when compared to the amounts the government spends on health and education. In a developing country, the government should get its priorities right as it faces tremendous pressure to deliver on fundamentals first [83]. There are very few funding mechanisms in other parts of Asia too for fine arts. Even if a few exists [84,85] these are limited to funding only traditional art forms [86] and people who manage them are not willing to consider innovative or experimental art [87]. Artists here complain that science based art projects will never be considered for any art grants when applied for! Funds from the field of science are not forthcoming too as the money allotted for science and scientific research is very meager in Asia. When contacted by me, both Department of Science and Technology, Government of India and Ministry of Cultural Affairs confirmed that they have zero funds to support science based art! Some of the people who run these wings were even surprised to hear about this form of art because they got to know about it for the first time when I contacted them! After six years of unrelenting search, recently I found one art funding organization in India which told me that "it would consider proposals for funding science based art projects"! But the people who manage it stressed that they could only give a very limited amount of money even if these projects were approved. At the end of the conversation I had with them, I realized the amount they offer cannot cover even 25% of the cost of a single science-art project in India! And before artists receive even this little monetary assistance for sci-art work, they would have to face more hurdles in the form of convincing the funding agencies about the relevance of their work, answering questions like why they want to pursue this art form and not the traditional ones and agreeing to several of the conditions imposed on them which are very difficult to follow. Would any sci-artist face such a situation for a paltry sum? No! Need I say sci-artists here either have to self-fund to engage in science-art or forget it completely? This really limits working capabilities of these people in the region. There is another aspect to this problem: as artists who are into science-art face severe difficulties to have shows here [88] (most of the gallery owners here neither accept science-art for the shows they organize nor represent the artists who are into sci-art), they have to travel to the Western countries to show their work or have representations. Most of the artists here cannot afford it. The low values of currency of several Asian countries are one of the important hurdles here [88]! I myself have faced this situation. Even though my work was selected and I got invitations for several shows, biennials, fairs, conferences etc. in the West, I had to forgo several of these opportunities opened up to me to promote my work as the value of Indian rupee is very low and spending half-a-million to one million rupees for each show is not possible for anyone unless a sci-artist is a millionaire here. Getting sponsorships in India for sci-art shows is extremely difficult as cultural and scientific bodies don't have funds and corporate sponsors don't think these would benefit them in any way! With no hope of ever getting a grant or a sponsorship from anywhere, most of the artists have to carry their crosses themselves here. Therefore, the artists will have to sell their works to generate money either for a living or creating works and organize shows. They will have to face another road block here. Market

seems to be the driving force for artists following only the traditional or decorative art forms. If the artists want to sell, their works will have to agree with the cultural conditioning of the art world's bigwigs in the region. Cultural bodies, art galleries and collectors won't patronize or accept works other than what they think is 'real art' or what art themes should be made of. And they are showing reluctance to rewrite the definitions of art at present. So experimentation is really a risky business for the artists here. Upcoming artists here have no choice but to adhere to the rules set by the big players. Old and well established artists can experiment but usually they don't because their old way of thinking doesn't make them accept science as one of the subjects for creating art. Although a few young generation artists in Asia are coming forward now to experiment, their work is mostly limited to taking the help of science and technology to create traditional and decorative art!

In the discussions we had on my network [88] and several other networks, most of the artists said that they didn't want to do sci-art because (a) there were no funds to support sci-art (b) there was no market for this form of art (c) they didn't think sci-art was actually 'art' (d) science was a difficult subject to deal with.

2. Reluctance of the people to accept new art trends: Dr. V.S Ramachandran, the well known neuroscientist who conducted scientific studies on the artistic processes, in his talks on interdisciplinary exchanges says continuity of cultures and old art forms since ancient times is one of the important aspects of the art world in Asia [89]. In Asia, culture and traditions are very deep rooted and longer lasting and therefore continue for generations passing through several centuries. These features are very crucial for the cultures here as they play an important role in preserving them. However, problems are arising because of the orthodox thinking that only the art that is handed over to them from their ancestors and well established art forms like decorative art are the "real art" and the new "strange science-art" is not art at all. This is one of the reasons for this form of art not forming roots and getting established. Changes occur at a very slow pace in the Asian art arena as people take a lot of time to accept "new experiments". *Reluctance of the art related people to accept science based art as a form of art is a huge hurdle in Asia.*

3. Education system: Art curators and art gallery owners (especially Mr. Nemiraj Shetty of Hasta Gallery, Hyderabad/ Bangalore) I had discussions with in India regarding the problem think the education system here is responsible for the type of situation we are encountering in this part of the world. According to them - the best and the most intelligent students here choose science subjects. Art is pursued by only not so bright and sometimes rebellious ones. They are not interested in interacting with science themes which they feel are out of tune with their nature. These people want to deal only with their emotions and the things they can relate to. In a way the artists in India are largely mentally disconnected from the science subjects! As art curators and gallery people are also from the same background, they don't deviate from their way of working. People who are from the field of science like me can experiment and do works in the way they want. But majority of the scientists here are too busy and orthodox ("right belief" of sticking to their own field) to venture into the art sphere. Most of the scientists I spoke to gave lack of time as one of the main reasons for not pursuing any work outside of their field.

4. Neglect by the people belonging to the field of science: Surprisingly, while organizing local and international science conferences and symposiums at museums and scientific research

institutions in Asia, traditional art is being given more importance and science based art is being ignored by the scientific community! I tried to convince some of the organizers of these conferences in India to consider science-art for the exhibitions etc. but was asked to participate in the conferences as a 'scientist' but not as an 'artist'! When requested a few times to give me a chance to exhibit my work, people who organize science conferences and symposia here showed admiration and awe at my work, but still didn't deviate from exhibiting traditional art in the shows arranged to entertain the international delegates! And they gave me a strange reason for this act of theirs: the people that are responsible for the 'cultural shows in scientific institutions' are from the department of culture and they don't approve science-art! This is a sign of lack of co-operation between scientific and cultural bodies. Science world's failure to convince the art world about the significance, relevance and the artistic values of science based art is a huge drawback. Some people belonging to both the fields of science and art here didn't even know science based art exists until I told them it does! After hearing about my work sometimes people call me to confirm that I really create science inspired art and try to verify whether it is really "art" and not just "science-illustration"! There is a positive part too in my story: my work had passed several tests and been accepted by people from both the fields of art and science as science based work that meet the artistic standards here. But one or two swallows don't make a summer! We need more of them to bring in the sunshine.

5. *Rigid attitude of the art world: The* thinking that sci-art should be limited to only people from the field of science [88] is one of the hindering aspects too. Majority of the people who are venturing into science based art in India are interestingly from the domain of science or people who have scientific backgrounds! A large part of the art world in Asia thinks that creating art is like a hobby and a relaxation process for the scientists and therefore, they won't be serious in protecting the standards of art. Mixing art and science is being treated as a threat to the artistic values here. There is also a mind set here that subscribes to the idea that rich people in the developed countries do science-art, especially Bio-art, for fun and it is not suited for developing countries in Asia where artists depend on selling their work to individual collectors for their livelihoods.

6. *Lack of understanding on how to correlate science and art:* A few people from both the spheres of science and art here told me that although they were interested in doing science based art, they didn't know how to co-relate science and art and 'culturize science'. Some of them asked me to start a few courses and train them on how to go about it. At present artists in Asia are using technology to create art because there are courses to teach how to do this. People from both the fields also say the way science related art is going in other places of the world doesn't match with their tastes as it is being created mostly not in the form of real art (that fits into their definition) but just as a glorification of science illustration or as demonstrations of scientific theories and phenomena [88] and therefore they are not interested in it. People in this part of the world want to learn how to create 'science based work that has real artistic values.'

7. *Non-cooperative Media:* Media in general in Asia was not forthcoming earlier in promoting science related art for the Mimetic effect [90,91] to take place. When I contacted the editor of a well known art magazine in Asia two years back requesting her to publish an article of Science-art to promote it through their journal, the editor asked me so many questions about the subject that took me a lot of time and effort to give replies to but in the end decided not to concede to my

request as publishing the article doesn't make the magazine more popular as this type of art is not well known in Asia! However, there is a silver lining to this dark scene. Some news papers that give preference to science [66] and science magazines and journals here are now coming forward to publish articles on science art interactions in Asia [92].

8. Lack of market: Artists and to some extent scientists too are not interested in creating sci-art in Asia because there is no real market for it [88]. " What is the purpose of creating science art," most artists here ask me, " Just to help scientists in communicating science? What do we get in the process of collaborations? Do scientists and the world of science only want to use us to send across their messages to the outside world?" Artists are not being inspired by the subject of science to create science-related art because of this reason. In the initial stages of my work related to science, although it was accepted as 'art', I was thoroughly discouraged by everyone in the art field in India by saying that nobody would support or buy my work here. 'Who would want to hang a picture of microbes on the walls of their living rooms?' was their argument. But to everybody's surprise I have sold some of my works by creating my own market here and people are hanging science based art works on their living room walls too! I don't think I need to say more here.

9. Ignoring Asia by the international bodies working in the science-art arena: Well established art science bodies at present are limiting their work to some specific science-art happening areas of the world. Collaborators' act of concentrating on those regions of the world where the happenings are more vivacious and ignoring other places is too causing severe imbalances. One should highly appreciate the work of Hackteria which is trying to remove these imbalances, bring the benefits of science-art interactions to the developing countries of Asia as well and help the people in the way it should be done here. [93]

However, I have observed some imbalances at the local level too. When I asked the groups of people from other parts of the world who had collaborated with the local art bodies in India in science art projects whom they had collaborated with and in which part of the country their work had happened, to my surprise, all the four gave me the name of a single art school in Bangalore! And the artists and the scientists in rest of India don't even know these collaborations are taking place in their own country! Why the international collaborators are ignoring other cities and towns and art or science bodies here and creating severe imbalances at the local level remained an unanswered question! I have noticed a similar situation in China too where all the science-art projects and collaborations are taking place only in Beijing, Shanghai and Hong Kong. Chinese from other parts of that big country have no knowledge about these collaborations! [88]

10. Inability of Sci-art projects to show immediate and positive results that last longer: In the developing countries of Asia, work has to be associated with development and it should have immediate and longer lasting effects for the governments here to recognize, get interested and allot funds for it. Despite all the positive noises made, at present science-art projects undertaken around the world are unable to work and show results in the way it should be done in Asia[101] 11. Well established sci-art organizations' refusal to accept and recognize the work done by people in Asia: It is not fair to say, "We will recognize your work only if you people do 'our type of work' based on our set of rules". People in Asia are doing their work in the most unfavourable and difficult conditions without any encouragement and support. It is not proper to

compare climbing Mt. Everest with a walk in the park (pray tell me, which one is more thrilling?!). Standards and work ethics differ from place to place. Although 'science' in science based art is universal, the associated 'art values' are regional in nature. People have to understand this to appreciate the science based art of different regions. The variations based on different cultures make science-art very rich. This aspect will be a huge contribution of art to the field of science and the work based on it. The indifference and criticism from well established sci-art bodies drive the sci-artists in Asia deep into a shell hindering and stopping the sci-art projects to take root and establish here.

Lessons Learned: "Life without problems is like a school without classes. You don't learn your lessons."

1. In a tradition-respecting region, you cannot expect immediate and positive responses to your new experiments. Change will be slow and innovative concepts will take time to get accepted. One should have patience to wait and unrelenting vigour to work on the minds of people.

2. In developing parts of the world sci-art movements should be associated with the progress of people and should be able to show immediate and longer lasting effects to get people, academies and governments interested.

3. Both artists and scientists should be able to self-fund sci-art projects in developing countries and therefore must be prepared for both hard work and slow progress (climbing Mt.Everest!).

4. The pioneers in less developed regions should not expect much in return for their efforts and should be able to cope with indifference and lack of funds and be able to absorb shocks from the developed world in the form of criticisms. They should try to do whatever they can despite all the difficulties to promote science art interactions.

5. In Asia, art standards are very high. Anything and everything will not be accepted as 'art'. Science-artists here have to meet these high standards to enter the art world, get established and achieve success. They should be able to both communicate science and preserve the artistic values of their cultures through their work.

6. To remove imbalances at all levels one should try to collaborate with people from different regions - not one particular place.

7. Instead of complaining that other people in your region are not coming with you, help create interest in science-art by removing obstacles in their paths by way of starting courses, writing articles and books and bringing awareness. Create a strong and big network of friends to popularize sci-art.

8. As the fund flows are very low in developing countries, here one should find ways to get maximum benefits out of minimum resources.

9. Instead of waiting for others to help you, try to help yourself by creating your own market.

10. To overcome the inertia created by the science-art scene in Asia and move forward, people here should interact vigorously with the fast ticking sci-art regions of the world.

11. One should be very active in both creating science based art and promoting it to get established and recognized.

12. You should strongly love the culture and creative part of science and believe in your abilities to withstand all the obstacles and go against the tide and live the dream of a polymath.

Suggested Actions:
 "If you show people the problems and show them the solutions they will be moved to act"

1. Media in Asia: Media in Asia has a huge role to play in creating awareness amongst scientists, artists and general public about the benefits of science art interactions. Promoting aggressively these interactions in the region by the media is highly recommended to make the people in Asia consider, accept, follow and reap the benefits they bring. If some people start creating science-art in this region, the mimetic desire catches up with others too if they come to know about it and they too start doing it! If somebody values it, others too start valuing it [90,91]. And it's pretty easy to transmit the value and use it positively. This is happening in the West right now, as several artists and scientists there are into science art. Why, I even think this mimetic desire was responsible for the overwhelming response got for the call given by the Leonardo network for submitting the white papers!
Using the influence of the number of cumulative adoptions - the number of people who already did science art or bought sci-art will have on the probability that there would be a new adoption of sci-art in that area as the phenomena are contagious - to promote science based art both for creating and marketing it [94] can only be done with the help of media.

2. Artists: (a) Scientists take cues from the art world - especially from the artists during the collaborative work - while deciding what art part of their sci-art work should be like. Therefore providing the right values and standards of art to the scientists by the artists is important for the scientists to properly co-relate science and art to create good science related art. (b) Artists should develop deep interest and jump on the bandwagon of sci-art with creative work instead of trying to just cling to it by changing the names from landscape art to geo-art and wild life art to eco-art![96] They should also stop doing 'sensational stuff' and concentrate on real 'developmental work'. (c) Instead of complaining that the world of science is trying to exploit them through collaborations [97], artists should use their creativity to do "marketable sci-art" and not just 'science-illustration type of work' so that the collaborations can benefit them too.

3. Art critics: There are various categories in science related art [98]. Critics should first learn all about them, try to distinguish one from the other and judge the works accordingly. They should not criticize sci-art works using the parameters of 'standard art' which would severely demoralize the artists who are trying to venture into the world of science.

4. Scientists: Scientists should not try to take science-illustrations, lab specimens and models directly into art galleries without first turning them into 'art' pieces because this is attracting severe criticism from art critics and curators [99]. Science can be brought into the domain of art only after co-relating both the subjects. Science and art are like oil and water and you need special skills to mix them. If scientists don't develop these skills they will fail to do justice to their subject and worse of it all they will have to face the music from the art critics and refusal from the art world like it is happening in several parts of the world. People of science should also convince the art world that they would take the artistic values and standards seriously and try to protect them while creating science based art. Scientists should concentrate more on inventing innovative art science based technologies to help societies in

developing countries. Mere creation of science based art doesn't suit present day conditions and the developing world [101].

5. Educators: Science art interactions cannot survive for long in a confused and unorganized state. There should be a methodical and knowledgeable atmosphere for it to grow and flourish. Educators must help in creating such an atmosphere. Educators can also help by starting useful and viable courses on the 'creation of science related art' and art science related technologies.

6. Industry: Industry in Asia should thoroughly encourage and support science-art interactive research dealing with science and tech based creative technologies as these might help in cutting costs and boosting the production in the developing countries.

7. Scientific organizations/ organizers of international science conferences/symposiums: Scientific organizations in Asia should include science-art exhibitions and talks on benefits of science–art interactions in their itinerary to promote it along with traditional art. In order to do this they should have healthy deals with the cultural bodies.

8. Organizers of Art and science shows, fairs, Biennials should encourage sci-artists from the developing countries by giving concessions and fee waivers to them.

9. Funding agencies: If the amount of money available is very less, funding bodies can still provide money to science artists and get it back too! This is how it is possible: They should collect works from the artists after providing assistance to create marketable science based art, sell the works and get their money back. Trade - not 'only aid' - helps in creating good quality work. This also helps both in the promotion of and creating market for this form of art.

10. People who are venturing into science-art : (a) In their eagerness to promote science-art interactions, people are trying to equate science with art which is not correct according to several critics who are averse to the idea of these interactions - alienating these skeptics more. This is not the right way to develop science-art interactions. Science and art are separate subjects [100] and we need different ways to deal with each one. The processes of scientific thinking and artistic thinking resemble each other at basic levels where the lines are somewhat blurred but go their distinguished ways as you proceed further. If the approaches are similar, science and art would have evolved into a single subject and wouldn't have become two special subjects they are. We must realize we can only bring these two subjects and people working in them together, build bridges, learn from each others knowledge and reap all the benefits the interactions bring. Any other approach will give more ammunition to the critics of these interactions. (b) Clarity is needed with regard to the direction science-art and science based art movement (if it is one) should take in the future. Do we want to integrate this form of art with the mainstream art or do we want to keep it as a separate entity? If we want to integrate our work with the main stream art, we should be able to convince the art world about the artistic values and the significance of our work. If we want to keep it as a separate entity using it only as a communication tool, artists may lose their interest very soon and science-art will have to limit itself to science-illustration, lab models and technology assisted art which may stunt its growth severely. Science-art interactions should be able to facilitate real

progress of the human kind. (c) Both scientists and artists should check the parameters especially- the depths- fully before venturing into each others' fields. Balancing science and art is very important in science based art without compromising science communication and artistic values which should be acceptable to both the communities as the right approach.

11. International bodies working in the sphere of sci-art: International bodies can help (1) by creating a market for science-art (there is scope for sci-art market promotion with regard to museums, educational institutions, scientific institutions and auction houses; one can even sell appropriate work to private collectors too like I do; auctioneers can be requested to consider sci-art too), (2) by rewarding the sci-artists with prizes for creating good sci-art and new technologies especially in regions like Asia, international bodies can generate interest in science among the art communities here, (3) by arranging large scale collaborations between art-science bodies from the most happening parts of the world and the scientific and artistic ones in Asia (they should not forget to advertise vigorously about these collaborative projects so that everybody in this region comes to know about them), (4) by thoroughly encouraging people and the bodies who are daring to venture into this arena in Asia despite all the odds, and promoting the work done here by mentioning it in their articles/books/talks etc. (for this to happen the international bodies should treat the sci-artists in Asia as only collaborators and not as competitors – how can the latter group compete with the former one anyway?!) (5) by asking prominent and well established art science bodies to erase the indifferent attitude towards the less developed science-art interaction areas,(6) by helping in developing funding mechanisms that can come to the aid of the people who are dealing with science-art interactions in Asia, (7) by organizing science-art specific global shows and fairs in Asia, (8) by promoting development-oriented sci-art projects in Asia, (9) by creating a true international body representing all the countries to oversee all these activities [95].

Appendix

Abstract: While North America, Europe and Australia are basking in the glory of new wave science-art collaborations and reaping all the benefits that these interactions are bringing, there are some parts of the world that are relatively untouched by these happenings! Asia, to which the Indian subcontinent belongs, remains almost immune to the developments happening around the world in this subject. With the exception of China, we hardly find any science-art projects here. Moreover, the few science-art interactions that are occurring are concentrated in China, India, Singapore, Indonesia, UAE, Iraq, Israel, South Korea, and Japan. Interestingly these areas with healthy scientific backgrounds are relatively high on the economic scales too in Asia. If we search for science-art interactions in this region, we mostly come up with science and technology assisted art rather than pure science art. This paper discusses the reasons for the dismal performance of science art and science based art in relation to the dynamics of the art world mechanisms in this region and suggests ways to remove the road blocks to make science based art flourish here.

References:

1. http://artradarjournal.com/2010/07/08/hong-kong-a-desert-for-new-me..
2. http://www.microwavefest.net/festival2011/index.html.
3. http://artdaily.com/index.asp?int_sec=2&int_new=57144#.UC20zqAoQps
4 .http://www.dnaindia.com/bangalore/report_learning-to-appreciate-the.
5. http://www.melalexenberg.com/paper.php?id=16
6. http://www.makemegenius.com/
7. http://www.cultura21.net/topics/sustainability/between-art-and-envi.
8. http://artradarjournal.com/2012/02/15/migrant-ecologies-innovative-.
9. http://www.timesofoman.com/echoice.aspx?detail=12773.
10. http://www.asianscientist.com/features/art-in-science..
11 .http://www.ted.com/talks/lang/en/aparna_rao_high_tech_art_with_a_se...
12. http://ibnlive.in.com/news/where-science-meets-art/260125-60-119.html.
13. http://psd.tutsplus.com/tutorials/tutorials-effects/100-artworks-fr...
14. http://johnyml.blogspot.in/2010/07/ready-for-four-some-show-visit-l.
15. http://www.mediacityseoul.kr/
16. http://kkartlab.in/profiles/blogs/creating-art-scientifically
17. http://www.basantsoni.blogspot.in/ http://www.ifaaonline.com/online-courses/organic-
18. http://timesofindia.indiatimes.com/city/hyderabad/Fine-art-Greater-...
19. http://www.mmail.com.my/story/eco-warrior-artists-27936
20. http://www.ianforum.com/photo/photo/listForContributor?screenName=3...
21. http://www.kkartfromscience.com.
22. http://www.sharadasrinivasan.com/index_files/aboutme.htm
23. http://kkartlab.in/video/aesthetic-universals-and-the-neurology-of-...
24. http://www.guardian.co.uk/global-development/2012/jun/05/indonesia-.
25. http://www.timesofoman.com/echoice.aspx?detail=12773.
26. http://www.greaterkashmir.com/news/2012/Jun/3/-mathematics-can-be-
27. http://portal.unesco.org/education/es/files/58030/12246005655Naim.p.
28. http://www.zyzyo.com/2010/12/top-10-technology-super-power-countries/
29. http://www.punksinscience.org/kleanthes/courses/UK04S/WV/Scientific
30. http://www.cid.harvard.edu/archive/hiid/papers/ecgasia.pdf
31. http://www.scientificamerican.com/article.cfm?id=the-worlds-best-co.
32. http://blogs.scientificamerican.com/observations/2012/09/28/best-co
33. http://www.clockenflap.com/
34. http://www.swissnexchina.org/background/news/13-may-science-art-exh.
35. http://www.worldscientific.com/doi/abs/10.1142/9789814324946_0005).
36. http://www.chttp://www.china.org.cn/english/MATERIAL/133971.htmhina.
37. http://www.china.org.cn/english/MATERIAL/133971.htm
38. http://www.tasie.org.cn/index.asp
39. http://www.chinadaily.com.cn/cndy/2012-11/03/content_15871515.htm
40. http://tasml.parsons.edu/?p=971
41. http://www.scientificamerican.com/article.cfm?id=china-science-rise...
42. http://artradarjournal.com/2012/09/03/chinese-art-collectives-provi...
43. http://nanobioart.com/blog/2011/10/art-science-symposium-city-unive...
44. http://www.britishcouncil.org/hongkong-creative-and-society-microwa...

45. http://www.artinasia.com/institutionsDetail.php?catID=1&gallery
46. http://www.mechanicalmirage.com/
47. http://www.japantimes.co.jp/text/fa20100723a1.html.
48. http://www.youtube.com/watch?v=oklLs35jtgE&feature=player_embed...
49. http://www.asianscientist.com/features/art-in-science-dancing-skele...
50. http://www.koreatimes.co.kr/www/news/art/2009/02/148_38982.html
51. http://anclab.org/Art.Science.2012
52. http://www.theasiamag.com/patterns/art-and-science-fuse-in-singapore
53. http://artradarjournal.com/2012/02/15/migrant-ecologies-innovative-. .
54. http://www.swissnexchina.org/background/news/13-may-science-art-exh.
55. http://www.worldscientific.com/doi/abs/10.1142/9789814324946_0005
56. http://www.guardian.co.uk/global-development/2012/jun/05/indonesia-...
57. http://www.artspak.com/historical_scientists.php
58. http://www.kkartfromscience.com
59. http://www.indianexpress.com/news/physicist-turns-artist-captures-b
60. http://www.sharadasrinivasan.com
61. http://en.wikipedia.org/wiki/Sharada_Srinivasan
62. http://www.artnewsnviews.com/view-article.php?article=previews&...
63. http://www.indianexpress.com/news/the-physics-behind-art/1016241/0
64. http://timesofindia.indiatimes.com/city/kolkata/Visva-Bharati-to-of...
65. http://www.ccmb.res.in/ccmb_arts/main.html)
66. "Where art and science collide" article published in Deccan Chronicle, Hyderabad, dated 12 August, 2012)
67. http://www.ccmb.res.in/ccmb_arts/main.html
68. http://timesofindia.indiatimes.com/topic/Sarabhai/news
69. http://srishti.ac.in/content/cema
70. http://2011.igem.org/Team:ArtScienceBangalore
71. http://kkartlab.in/group/News/forum/topics/art-and-tech-interactive...
72. http://mpiwg-berlin-mpg.academia.edu/SonjaBrentjes/Papers/631900/Th.
73. http://www.wamda.com/2012/09/iraq-reborn-art-science-hub-through-ba...
74. http://www.wam.org.ae/servlet/Satellite?c=WamLocEnews&cid=12899...
75. http://www.uaeinteract.com/docs/Science_and_Arts_exhibition_shines_...
76. http://www.timesofoman.com/echoice.aspx?detail=12773)
77. http://cultureshuk.com/2012/08/25/9-leading-israeli-artists-selecte...
78. http://scienceblog.com/community/older/2001/F/200115979.html
79. http://www.melalexenberg.com/paper.php?id=16
80. http://www.haaretz.com/weekend/magazine/the-art-of-science-1.217559.
81. http://www.masterstudies.com/Masters-Degree/Biological-and-Life-Sci....
82. http://www.livemint.com/2011/01/27232508/Art-and-philanthrophy-an-e...
83. http://www.bbc.co.uk/news/entertainment-arts-11569883
84. http://www.transartists.org/article/funding-asia.
85. http://www.asianculturalcouncil.org/?page_id=12
86. http://srtt.org/programme%20grants/programme_grants.htm
87. http://www.asiaartfunds.com/en/grants.html
88. http://kkartlab.in/forum/topics/my-research-paper-on-science-art-in...
89. http://kkartlab.in/video/aesthetic-universals-and-the-neurology-of-...

90. http://www.uibk.ac.at/theol/cover/contagion/contagion3/contagion03 .
91. http://blogs.scientificamerican.com/scicurious-brain/2012/07/30/you...
92. http://www.asianscientist.com/features/art-in-science
93. http://hackteria.org/?p=1468
94. http://esciencenews.com/articles/2012/10/18/solar.power.contagious
95. http://kkartlab.in/profiles/blogs/is-there-a-necessity-for-an-inter...
96. http://kkartlab.in/profiles/blogs/now-landscape-photography-is-beco..
97. Nature 477, 278–279 (15 September 2011) doi:10.1038/477278a
98. http://kkartlab.in/group/scienceart/forum/topics/science-based-art-1
99. http://kkartlab.in/profiles/blogs/an-interesting-comment-and-criticism-on-science-art
100. http://kkartlab.in/group/scienceart/forum/topics/differences-between-art-and-science
101. http://kkartlab.in/profiles/blogs/tall-claims-and-failed-proof-of-sci-artists

Bridging the Divide: Collaboration, Communication and Education in art And Science

http://wp.me/P2oVig-k2

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Abstract
As an artist and educator who works collaboratively with scientists I am interested in the potential for developing meaningful discourse and research that engages at the interface between disciplines and provides fertile ground for creative enquiry and experimentation. Interdisciplinary research and collaborations in the field of art and science embrace the potential to explore diverse approaches to understanding the nature of the world we live in and the development of ways to communicate this. In this short paper I will be considering the potential in collaborative investigation and the experience of establishing the MA Art and Science at University of the Arts London.

The creation of a new interdisciplinary Masters programme: MA Art and Science at Central Saint Martins (CSM), University of the Arts London (UAL)

The MA Art and Science is an interdisciplinary course that I have been responsible for initiating and developing at Central Saint Martins, University of the Arts London in the UK. My interest in this area of research stems from professional experience as an artist collaborating with scientists and in areas of discourse and pedagogic research that engage at the interface between disciplines providing fertile ground for enquiry and experimentation.

In proposing the creation of the Masters programme in Art and Science at CSM I wished to reflect the considerable interest in art-science relationships internationally, evident in collaborations, publications, conferences, exhibitions and media devoted to exploring this area.

There is also a desire among students to engage in areas of research that are not limited to a particular perspective, and a keen interest in exploring creative possibilities to be found in a range of disciplines and fields of enquiry that are embraced by art and science. Consequently, following completion of an exhaustive 2 year validation and consultative process, the MA Art and Science is now into its second year of delivery (http://www.csm.arts.ac.uk/courses/ma-art-and-science/).

Context

We live in an interconnected world and the way in which we acquire and disseminate knowledge should seek to build upon this. While we may have different approaches internationally to how education is structured and delivered it is important to find ways to enable the exchange of ideas, and find the means to do this which enhance understanding and can lead to the development of new ideas, technologies and applications (see suggested action #2).

The English educational system continues to evolve although historically student progression to Higher Education has followed a path of increasing specialism toward University entry resulting in a progressive narrowing of subjects studied by students at pre-Degree level. Typically, there has been a tendency to make study choices that lead to specialism within the arts, humanities, sciences, law or medicine although Universities are increasingly aware of demand for interdisciplinary programmes and are making provision for this.

The MA Art and Science is conceived to be attractive to individuals from science, humanities, arts, design and engineering backgrounds. The subject itself embraces the potential to explore diverse creative approaches to understanding the nature of the world we live in and the development of ways to communicate this, and the curriculum is devised to enable each individual to bring to the course their own experience and insights while gaining new knowledge, skills and understanding as the programme progresses.

To date applicants have come from a healthy range of educational and experiential backgrounds, including science, arts, design and humanities graduates; scientists, artists, designers, performers, linguists, film makers, and those with professional or other work-life and research experience. For some the course is attractive as a means to further their studies in a field of interest having already completed postgraduate, and in a couple of instances, research degrees.

Development

In developing the course content it has been necessary to give particular thought to the context of the institution where it is delivered and the resources available in London, nationally and internationally that support the students' research and ambitions to develop their ideas. University of the Arts London is an internationally recognised arts institution but it does not have a science faculty. Consequently, the programme capitalizes on the strengths the University has to offer, particularly in the fields of arts, design and innovation, and compliments this with external resources that address areas of expertise that had not formerly been available within the institution. The establishment of the MA Art and Science course also contributes to the University's expanding access to a broader intellectual and research base.

If I were to have the opportunity to develop this programme within a University which offers the arts, sciences and humanities I could envisage different approaches to how this might be done and would be excited to explore these possibilities. But I have found that working with the University of the Arts has allowed for a creative approach to curriculum development and planning and encouraged the establishment of contact with external resources at an early stage in the planning.

This has resulted in an outward facing programme which builds on the possibilities of working with a range of external research institutions of international standing (Wellcome Collection, British Library, Wakehurst Place Kew Gardens, Gordon Museum, MRC Institute of Neuropharmacology Oxford, among others) and access to experts in a wide range of science subjects who enhance the course offering and enable students to engage with professionals in their specialist fields of study. This forms an important part of the curriculum allowing research

to be experienced in context and encouraging an investigative approach to learning and network building.

This is complemented by studio based activity taught by a team of artists, designers, and scientists whose work embraces a wide range of approaches enabling students to learn about processes of visualizing and making, the results of which are evident in work presented for public exhibition and as part of their project research. This is another significant component of the course and one that has proven attractive to students wishing to explore their ideas across a range of media and to develop new problem solving and visualization skills that translate and communicate across disciplines.

The interdisciplinary MA Art and Science course has also proven to be attractive to a group of students who may not otherwise have thought to apply to the University and from the outset we have recruited as intended from a spectrum of educational and professional backgrounds in the arts, humanities and sciences. The nature of the interdisciplinary subject choice, and that this is the first time it has been offered as a distinct Masters programme with a qualification in the subject of Art and Science, appears to be a significant factor in early success in attracting applications. The course appears to be addressing a genuine interest in the field of art and science and it is my expectation that this will continue to grow. As more courses that engage with this area of interdisciplinary research emerge internationally, so the subject should gain a pedagogic critical mass with a resulting evolution of discourse and creative output.

The aim of the MA Art and science is also to encourage students and graduates to undertake research and production that may have implications for discovery and invention across and within disciplinary fields, with the potential to develop innovative ideas and work that broaden the horizons and understanding of the subject.

Collaboration

Developing discourse and research that engages at the interface between disciplines provides fertile ground for creative enquiry and experimentation. A collaborative process between scientists and artists engenders a mutual respect for different approaches to discovery and invention and a preparedness to question convention.

It takes time to build relationships of trust and awareness that, while unpredictable, can result in collaborative endeavour leading to new insights and ways of thinking that inform future research and experimentation. For meaningful exchanges to take place scientists and artists need to comprehend one another, and in the process benefit from appraising their research from alternative perspectives.

Exploration and expression by visual means offers one approach to achieve a greater understanding of what we encounter and conceive for both artists and scientists, and encourages a wider audience to engage with the process.

In our endeavours to comprehend we make connections between experiences, render ideas tangible and conceive and test propositions and hypotheses in ways that enable others to broaden

their vision and enhance their quality of life. This is a human endeavour that is served well by a creative correspondence between scientists and artists.

On the MA Art and Science students are offered opportunities to engage in and develop their own collaborative projects with scientists, designers, artists, researchers and other institutions supporting research in art and science. This has already resulted in exhibitions and publications ('A Nervous Encounter' with the Oxford MRC Institute of Neuropharmacology: http://blog.nervousencounter.com/; and an exhibition 'Discoveries: Encounters between Art and Science' planned at the British Library for March 2013), with new collaborative projects in the pipeline.

One of the key issues facing the development of art and science discourse is the approach the science community adopts in seeking engagement with this interdisciplinary area of research. For some scientists there is a personal interest and realisation that alternative perspectives allow for potentially novel developments, methodologies and solutions to problem solving. Public engagement has been another driving factor, as funding for research in science is increasingly related to the need to satisfy requirements to explain this to a wider audience, particularly where public sources of funding are involved.

There is a concern that art and artists are perceived as offering a user friendly interface for science to 'get its message across', and it is important to ensure that collaborative projects are undertaken in ways that enable the potential for shared insights to mutually advance knowledge in the related fields of enquiry (see suggested actions #1-3).

While the MA Art and Science course is still young we have already begun to build collaborative relationships with science and arts institutions and the development of networks with individuals and organizations interested in exploring art-science relationships. This benefits the students in their studies and encourages them to make their own connections and associations that should prove invaluable in establishing their creative, intellectual and professional practice. It should also encourage a greater sharing of knowledge and potentially pooling of intellectual resource between educational institutions and I anticipate that that this will evolve internationally. Students today are used to tapping into networks of knowledge that transcend national borders and are increasingly seeking ways to advance their understanding across a range of approaches, platforms and media (see suggested action #2).

SUGGESTED ACTIONS:

Funding streams for the sciences and arts and humanities may be quite distinct and do not necessarily embrace or encourage an interdisciplinary approach to innovation and investigation.

Suggested Action 1

Public research funding should be inclusive of, and make provision for, interdisciplinary research across the arts and sciences. Initially, where relevant, publically funded research grant proposals could be requested to address interdisciplinary research potential.

Stakeholders: Foundations, Government Agencies, And Other Funders; Universities and Educational Institutions; Administrators In Educational Institutions; Educators; Scientists; Artists; Designers; Industry

Suggested Action 2

Art and Science research is international in scope and could benefit from a comprehensive and accessible published and peer reviewed knowledge base.
Suggested Action #2:

An international web-based network and database could be established pooling expertise and innovation among educational institutions internationally, that could host an accessible database of historical and current research projects, publications, exhibitions and other manifestations relating to art and science research.

Stakeholders: Universities; Libraries; National Academies; Educators; Students; Researchers; Public; Artists; Scientists; Designers; Engineers.

Art and Science researchers and graduates have the ability to contribute innovatively to industry.

Suggested Action 3

Establish an international network of research placements with companies that could benefit from professional exchange (i.e. with appropriate safeguards for commercial, patent and copyright) with arts and science researchers, graduate and doctoral students.

Stakeholders: Students; Graduates; University Research Innovation Centres; Industry; Educators; Administrators in Educational Institutions

A Case Study in IP Arising in Art/Science Performance Research and Transdisciplinary Collaboration

http://wp.me/P2oVig-mV

Coordinator: Josie E. Davis

Date: November 15, 2012

ABSTRACT

In this paper, I will discuss the projects and practice of the art/science research collective Davis & Strathmann. I will use Davis & Strathmann as a sample case study in transdisciplinary, collaborative, practice-based performance and design research with a unique history of unresolved trademark and intellectual property conflicts between members. I will consider the history of two projects, Sink and Hunter/Symbiosis, as an example of work conceived by the author and developed as part of a collective mobile exchange between the U.S. and Argentina and, later, as part of a six-week art/science residency at the Helen Riaboff Whiteley Center at Friday Harbor Laboratories. I will focus on the expertise of the collective in audio and media production, performance and critical studies, visual design and specifically, on the application of these practices toward the field of art/science research.

Issues arising from shared practice including divergent views on the role of performance as documentation, mutual access to photography and media archives, process versus product, ethics and professional discourse, and transparency are examined in the context of these works, with attention to the dissemination of the collective and role of the author in retaining artistic ownership of image rights, concept application, and administrative access. In particular, this study will examine a series of unresolved IP challenges facing the author over a period of two months following the end of the residency at Friday Harbor Labs including the abuse of online administrative permissions, exploitation, irresponsive behavior toward the collective identity, threats of legal action and IP misconduct in regard to the exhibition of future work, subversive efforts to deface fundraising platforms, and the withholding of media for personal gain. Furthermore, this study will examine the actions by both members that contributed to these issues, how certain actions may have been avoided, and steps currently taken by the author to prevent the recurrence of IP conflict and to protect future stages of these and additional works. In closing, the study will offer suggested actions for how these lessons can be observed and utilized by transdisciplinary collaborations seeking to avoid IP conflict in their respective field.

I. INTRODUCTION

In 2010, the author (Davis) began a two year transnational collaboration (her creative partner will herein be referred to in the context of "the collective" or "the collaboration") that later dissolved in response to an unresolved dispute over the joint-authorship of work. This dispute coincides with the presiding and, increasingly common in SEAD, issue of intellectual property rights. Without practical communication platforms, cross-disciplinary environments lack the common ground needed to sustain innovation – this paper reevaluates these and other issues,

focusing on how a rise in distrust can be resolved through sustainable and efficient research practices. I will place this conversation in the context of two projects, Sink and Symbiosis, addressing the relationship between process and product, success and failure. Finally, I will address roadblocks, strategies, and approaches for conflict resolution and an overall understanding of copyright and trademark rights as they apply to individuals working jointly in the creative domain.

II. THE COLLECTED WORKS – PROJECTS

Hunter-Symbiosis

> What is interactivity, I thought, but expertise in structuring and restructuring complex and shifting relationships; what is parallel processing but expertise in handling multiple simultaneous events, skillfully choreographing continuous and interruptible tasks; what in the cybernetic and surveyed body/self but one that can sustain integrity with blurred boundaries and even multiple bodies and identities as in the case of childbearing? (Richards 1996: 259)

The Collective's first experiment, Hunter-Symbiosis, responds to the need to "explore a new body" (Richards 1996:258) through the performance and documentary-analysis of human-microbial relationship. The project sought out the inherent and emerging social pathologies erupting from what could at best be coined the symbiotic collision of two dissimilar organisms or acts, and the resulting performances belonging to such type of gesture.

The relationship between "disciplinary formations, disciplinary subjects, and their objects of study" (Kirshenbalt-Gimbaltt 1999: 47) informs and challenges preconditioned behaviors of normalcy in an economy of social contagion evolving from this symbiotic threshold.   Davis sought to disarm and engage the audience in public space by examining the absurdity of "living-with": documenting her relationship with a mycelial growth (herein referred to as "Hunter") as a prosthetic extension of the artist's body. As in a multitude of performance works, the public space functions as an arena for spectacular interpretation, where the audience is an active participant in the determination of work that is both art and science.

Materials & Methods

The experiment recorded the growth of four mycelial sub-types on a 1/8" malt agar growth medium: *P. ostreatus* (blue and white oyster), *Hericium erinaceus* (lion's mane) and *Saccharomyces cerevisiae* (yeast). Each sub-type was selected based on the following considerations: (1) widespread and reproducible growth within a 2-3 week time frame (2) aesthetic appeal (3) hazards to human health (respiratory and immune), as open studio facilities led to the inevitable influx of bacteria. Under these conditions, the project was viewed as a pilot - an experiment supporting further investigations: oyster mushroom sub-types proved the most adaptable and widespread, with fuzzy white growth patterns marked by red, blue, purple and green "splotches" of bacteria. Runs extended from 3 – 14 days.

Malt agar was used as a growth medium and as a protective coating between Hunter and Davis. When transferred to the body (cheekbone, torso, left arm and hand), the agar dried into a transparent film layering the skin but not entirely visible to the spectator. To this effect, Hunter became a reflection of the spectator's own comfort in developing a relationship with (each other) and the work. The relationship was defined as everything and nothing – a performance, an infection, bad make-up, an open wound. While this could be coined as an early "success", Davis has since considered additional methods for growing Hunter directly on the body with and without a growth medium.

The experiment concluded on June 12-13 with a two-day photo shoot and performance at a local farmer's market and three additional locations across the Island. As vendors and Island residents interacted with Davis, this fear of not-knowing became a kind of viral social contagion. Davis treated the "situation" as normal and challenged the spectator to do the same, focusing her attention on commonplace activities like shopping for vegetables and talking with locals. Particular attention was paid to the gesture: purchases, shaking hands, hugs, tasting food samples, physical exchanges driven by the desire to "fit in" that amplified the performance. The team shot between 1,500 and 2,000 still life portrait (unedited) of Davis and Hunter at sites including the market: a private and locally owned pond; the floor of an unfurnished concrete basement; and portraits of Davis and Hunter in the studio at the labs.

The Relationship

Living-with can be understood as an awareness that the [said] object is a construct of both affect and emotion and is therefore an agent of desire:

> "I'm having a lot of difficulty naming the organism … [I]t feels strange, talking
> [to something]. Because, as I said before, it isn't a plant or an appendage … [I]f I
> name something, we become affiliated in a domestic, human way. We
> are present." (Davis 2012)

Davis describes her relationship to Hunter as an emotional attachment evolving between the (1) remote object/subject (2) nurturing/maternal caregiver/child/sibling and (3) spouse-domestic agent (2012). Davis treated the studio "lab" space as both home and work - sharing meals, reading the paper, listening to the radio, checking temperatures and humidity rates, running the

autoclave, indulging in a dance party – actions that, on any given day, might be a way to nurture or pass the time. These actions reflected growing sentiments between Davis and Hunter and the simultaneous discord felt between participating members of the Collective, an issue that is discussed later in the context of diverging processes and outcomes in the work.

SINK

What does it mean to re-produce objects of function and is it worth exploring a relationship to the utilitarian as an object of decay? To what extent is our universal relationship to the object defined by permanence and function? The construction of an over sized acoustic "instrument" through which the spectator shares in the temporary decay of the object, Sink put these and other relationships into question. More architectural modeling than a performance in space, Sink is an investigation of both temporality and function in utilitarian design and acoustics. Early conversations wrapped around how and where to place the work and how landscape and ecology shaped the acoustic and conceptual drive of the piece. Both urban and coastal sites were considered, inviting the audience to intrude or stumble upon the work through the unexpected.
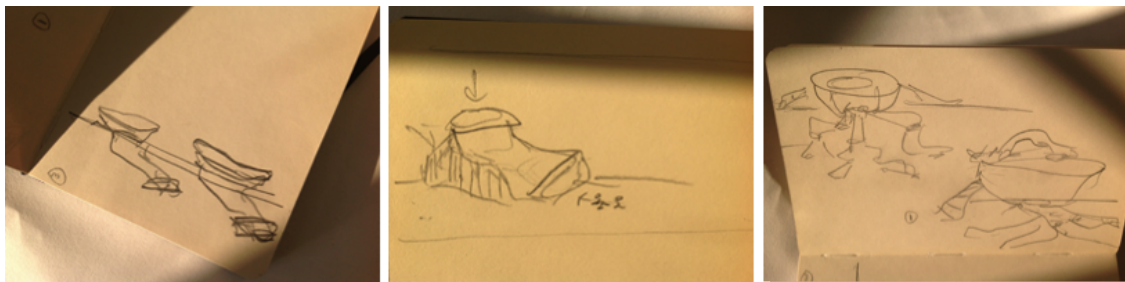
Materials & Methods

Ecovative Design® (see the company website www.ecovativedesign.com) is an advanced start-up design and manufacturing firm specializing in the supply and demand of biodegradable household mycelium products. In 2011, the firm expressed an interest in the project; leading to a two year engagement and site visit during which both teams discussed the short and long-term logistical measures behind the fabrication of gallery models and scalable designs. Production and modeling of Sink, was halted in June 2012 due to the unanticipated two-week shipping delay of over 40 cubic feet raw materials from New York to Washington. Resulting in 10 days of non-refrigerated conditions, the materials were overheated and environmentally distraught when arriving at the studio with less than a week remaining for the experimentation, design, manufacturing, and shipment of two models back to Chicago. (Davis/Ecovative, pers. comm.). Regardless of the circumstances, the residency provided ample time to flush out designs and test early stage fabrication. Wood pallets and PBC piping were recycled and fabricated to create internal casings, molds, and frames. The two models in part reflected the subtle thematic and design deviations between the two artists: a tube or vessel channeling bodies and sound through an entry/exit; plumbing fashioned after bull kelp; a larger than life acoustic instrument.   Davis has since enrolled in an architecture seminar at the University of Illinois Chicago exploring new tools and design options for the piece.

II. Issues and Action

Sink and Hunter-Symbiosis offer an integrated approach to the cross-humanities and sciences; not only in the concept and fabrication of transdisciplinary practices but in reevaluating methods of communication best suited for making these kinds of projects a success. This paper will now address selected roadblocks encountered by the author and proposed methods for action: (1) improving communication and trust via [trans]national and -disciplinary research practices (2) "product" versus "process" driven decision making and the dissemination of the collective approach (3) fundraising ethics and crowd-source platforms (4) joint-ownership and IP image use rights and (5) web transparency and permissions.

Transnationalism fosters cross-disciplinary engagements and in-depth perspectives between individuals and groups in the arts, sciences, and humanities to which the localized collaboration is otherwise not exposed (Salter and Wei 2005). Sink and Hunter-Symbiosis evolved from a discourse between two members who at the time lived in the U.S. (Chicago) and Argentina (Buenos Aires), respectively, generating a two-year chain of emails, chats, skype calls, design sketches, and other. Issues arose as these "non co-present methods" (Salter and Wei 2005) off set the reality that the collective had only met once in passing whereas the bulk of the collective development occurred online. Davis re-located to Chicago later in 2012, although face-to-face methods for communication did not mirror the efficiency of the mobile relationship already in place. In other words, the collaboration suffered something similar to a long distance e-couple meeting for the first or second time in real-time and space. Without the ability to communicate effectively in real-time, the varied perspectives and preferences for design resulted in a complex, under-realized and overly conceptual collaborative framework:

> "Fundamental challenges facing communities of interest are found in building a shared understanding of the task at hand (which often does not exist upfront, but is evolved incrementally and collaboratively) … Members of communities of interest need to learn to communicate with and learn from others who have a different perspective and perhaps a different vocabulary for describing their ideas. [They need to] establish a common ground and a shared understanding." (Ernesto Arias 1996) (Salter and Wei 2005)

The Collective assumed their shared practice by combining disciplinary and theoretic expertise not limited to audio production, visual design and multi-media fabrication, performance and critical race studies, public art, and the voice; art/science practices not withstanding. Hunter-Symbiosis was developed as live performance but, more importantly, a multi-media documentation poised for exhibition (museum, gallery, web portfolios, etc). All components of the work from equipment rental to blogging contributed to this anticipated outcome. Similarly, Sink was, at its earliest invention, a literal "sink large enough to sing inside of," (Davis/Greenleaf 2009) while evolving into a scalable acoustic "instrument." But is the success of a collaboration quantifiable only by these kinds of linear results or, rather, by a series of [learned] failures and processes from which the result is achieved:

> "The work on 'sink' in Friday Harbor was, in some ways, a documented failure, while my understanding of 'Symbiosis' is now infinitely more resolute .... more

importantly, things happened … [T]he success is in the result of everything I didn't plan." (Davis 2012)

Judith Thomsen Klein suggests that "Transdisciplinarity is simultaneously an attitude and a form of action." (Klein 521 2004). In other words, both the desire for action and the act itself must be present in order for research to be considered a success. But how does a collaboration create work that may or may not collectively "synthesize" in order to reach a cohesive means to an end (All Collaboration 2010, Klein 2004: 519-523). In other words, how deeply embedded are we in the work we make? Residencies in particular require the emotional and physical commitment of the individual in building trust and performing a common goal: "[C]ollaborative residencies are much like living with your significant other, and that is to say, do you really want to live with someone so soon?" (Davis 2012). Davis' investment to each project intensified as communication within the collective became increasingly vague and tense. Davis believed that the abbreviated timeframe with regard to materials offset the pressure to produce [said result] and to focus instead on 1) presenting high quality documentation and exhibition of Hunter-Symbiosis and 2) crafting and reevaluating a cohesive design and fabrication strategy of Sink that could be applied to forthcoming proposals. (De Jong 2010). The residency and the months preceding were self-documented by Davis through low-resolution photography, blogging, sketches, extensive journal entries, and video/hand held audio clips in a relationship that is both a product of conception and an experimental act (Kirshenblatt-Gimblett 1999). Without any particular goal in mind, these "outtake" archives reflect the increasing dysfunction within the collective while exhibiting Davis' emotional attachment to the work and the desire to interact with residents and researchers - prompting further investigations within each project:

> Undertaking to perform the experiment remains highly valuable, investigative study, acting on a trial basis. It will become obvious that getting the experiment to work demands a great deal of embodied capabilities, many of which are no longer known at all well. Therefore success in repeating the trial depends above all on the improvisational work and knowledge of the researcher … gestural knowledge in doing the experiment represents a resource in its own right, which complements the usually static representations of past practices like historical texts and material objects. Doing the experiment, and recognizing the troubles encountered in getting it to work, creating an awareness of the behavior of the historical experimenter and the practices, possibly unarticulated, which are indispensable for the performance of the experiment.
> (Sibum 1995: 28)(BKG 1999: 49)

In other words, the risk involved is in the capacity of a team to perform and embrace the unknowns in an act that translates concept and more importantly, does.

It is also possible that both members of the collaboration fell on opposite sides of the "trust continuum" (see All Collaboration "Building and Sustaining Trust"). As is an issue in many collaborations whose early stage development is defined by distance and/or discipline, each participant held strong preferences for how to build a slow and steadfast – but trustworthy – relationship. Collaborations are defined by the individual pooling of talents, past experiences and future goals (All Collaboration). As is the case here, trust does not always develop

overnight, and any number of activities can be cause to remove the individual from collective accountability and invite distrust into the collaboration.

One of these acts is the subversive and unpronounced termination of a fundraising campaign launched by the Collective in the spring of 2012. In June 2011, the collective received joint 501c3 status through the fiscal agent Fractured Atlas, stating that the two artists would likely pursue additional collaborations in the future and therefore profit from a wider net of funding options. (Hubbard, e-mail messages to author, May 2011). The following year, the team planned and launched a month long Kickstarter campaign to supplement additional project expenses for the work described in this paper. If used correctly, crowdfunding saves costs and alleviates many of the small tensions and administrative "to-do's" on a long list of deadlines by generating funds from vast numbers of people with a common interest in helping a charity, creative, or software-savvy project reach its goal. However, the outcome of this type of funding is unpredictable to say the least, either in the amount of money raised or the credibility of a design (see HongKiat.com on "Crowdsourcing: Pros, Cons, and More").

Three days before the end of the campaign, the Davis received a series of emails announcing the retraction of funds by nearly half of all major donors. (Davis/Kickstarter admin pers. comm.). While the nature of both projects had changed course, Davis maintained daily and weekly updates on facebook, twitter, Kickstarter, youtube, and the website to ensure that audiences understood the purpose and application of funding as things progressed. The retractions led to the failure of the campaign and the eventual termination of the collaboration after Davis personally funded all remaining project expenses. In weeks following, her collaborator proved overwhelmingly irresponsive - any attempts at communication and resolution were ignored (in regard to the failed campaign, image editing and hard copy transfer, budgets, studio wrap up, etc.). Davis later received an email dismissing any history of the collective:

> This may come as a surprise to you, but our residency was never a collaboration […] In response to your last email … I asked all of my friends and colleagues to retract their contributions […] I documented my concerns, which were with regard to my own ethics …. As to the images I am not giving them to you. I will address the legal and logistical details when I examine my project, hopefully during the spring of 2013.
> (email to Davis, July 16 2012).

Without proper written agreements, any form of shared ownership in property and image use is an uphill battle. During and immediately following the performance of Hunter-Symbiosis, the photographer (whose name remains anonymous) transferred nearly 2,000 high-resolution digital images to a 'shared' hard drive, at which time Davis was not present. Davis has since been prohibited from viewing, editing, and accessing any of the aforementioned images, a conflict prompting this publication.

Copyright Law states, "[T]o establish co-ownership of the photograph copyrights, the defendants must show that 'the parties intended to be joint authors at the time the work was created [and] . . . that [their] contributions to the works were independently copyrightable.'"[xxix] (US Copyright 2012 and see also, Filler 2007). In the simplest terms, a work can have multiple owners ("tenants in common" – see also Stanford Copyright & Fair Use) if two or more people contribute to

making the work. But authorship and ownership of an image are in many ways implicit. Authorship is defined as 1) the first owner of copyright 2) the creator of the work or 3) the employer of the person making the work i.e. commissioner (see Stanford University Libraries). "In no case does copyright protection for an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated, or embodied in such work. [102(b)]." (US Copyright 2012). While Davis conceived of both works, this does not guarantee ownership: Davis is now in the process of reviewing over two years of documents with an IP attorney to claim joint-authorship with her former collaborator, a right which was taken for granted (see also Copyright Law Sect. 106: Exclusive rights in copyright works). Davis is motivated not only by accessing the images but in understanding and learning from her mistakes so as to prevent future damages and misuse. As the primary subject of the photograph, Davis is aware that at no point in time can the image(s) be displayed (reproduced, exhibited, etc) without her permission (Davis/Davis, pers. comm..). Additionally, The Illinois Trade Secrets Act defines misappropriation as the "disclosure or use of a trade secret of a person without express or implied consent by another person" (Sec. 2b). In other words, the act or threat of action (as might be seen in the display of Hunter-Symbiosis web or print images in exhibition or, let's say, as work samples in a grant proposal by a former collaborator – misappropriation gives 5 years for filing such a claim) with regard to the knowing misuse of property for gain.

So how can we prevent this kind of conflict and loss, looking ahead so work is created for the benefit of everyone involved? The mistake is in disregarding written agreements, as is otherwise a baseline precaution in most professional collaborations and a standard procedure in almost all of the author's former and ongoing collaborations. Written agreements – contracts - are not only a way to outline the team's individual contributions and goals, they are a non-threatening and preventative legal aide that can be used at any point down the road if and when things get muddy.

The final issue involves how to effectively link the private and public domain while fostering transparency in the workplace – openly communicating the agenda and challenges of collaboration through shared documents and images. The website for the Collected Works was designed as a transparent online domain where audiences could participate in unedited conversations informing the work. In doing so, the collective exposed readers to issues facing each project while simultaneously advocating for solutions.

Over time, informal domain securities prompted the abuse of passwords and web permissions. Davis first granted and later removed all web permissions after her collaborator became irresponsive to emails looking to tie up loose ends and to address how and if the collaboration would continue. [He] further responded by redirecting the web address and removing the title and various content for the website. This is significant considering the lack of compromise and the fact that [he] held no administrative permissions or authority to access any online accounts belonging to the author at the time. Davis edited the site to its previously published state, changing all account information (passwords, emails, etc) for the site and linked domains, in addition to blocking her collaborator on professional and social networking accounts. Sponsorship with Fractured Atlas was terminated and reissued in 2012 supporting the work of Davis as a sole proprietor.

III. SUGGESTED ACTIONS

Summary
In order to move forward in the field, individuals seeking out new collaborations must understand their rights to the work being produced. This is the responsibility of the individual as much as the collective; future projects and practices by the author rely heavily on the exploration of intellectual property in addition to contract negotiation between transdisciplinary institutions and programs. As SEAD practices are adopted into the broader fields of the humanities (cultural, visual and performing arts in particular), it is important to note how relationships between discipline are communicated in reaching a shared goal: museums curator who showcases work is on a different schedule than privately owned developers or architects involved in funding or design; a researcher might be at odds with a less analytical team of artist-in-residents. Regardless, it is this overlap in discipline that prompts ingenuity and nurtures a future of shared communication platforms. The suggested actions listed below draws upon issues and lessons described in the paper above, summarizing the immediate need for transdisciplinary teams to work through conflicts of interest so as to educate others on the future of effective performance research.

Obstacle #1: As shown above, communication in transdisciplinary collaborations can suffer from a failure to establish common ground (shared interest), particularly when working between long distances over time.

Suggested Action: Invite DESIGNERS to create mobile apps and interactive workshops in e-communication and conflict resolution.

Obstacle #2: Many SE-AD participants are unaware of their rights to an image as author, owner, or subject, and are therefore subject to trademark violation.

Suggested Action: Prevent intellectual property and trademark violation against ARTISTS, SCIENTISTS, DESIGNERS, EDUCATORS, HUMANITIES SCHOLARS, and ENGINEERS by reviewing current work (if violated) with an IP attorney to determine a course of action. Develop written agreements between ARTISTS, SCIENTISTS, and HUMANITIES SCHOLARS outlining the goals and objectives of ongoing collaboration and research.

Suggested Action: Provide contract templates to EDUCATORS and DESIGNERS for publication and download on opens source websites and integration into core curriculum.

Suggested Action: That NATIONAL ACADEMIES and EDUCATORS create a network of transcontinental conferences addressing the rights and prevention of IP.

Suggested Action: Maintain archives of work produced by ARTISTS, DESIGNERS, ENGINEERS, STUDENTS, EDUCATORS regardless of "quality." Make use of available documentation, contacts and resources, and knowledge to help you and your project move ahead.

Obstacle #3: Funders often return to SE-AD professionals looking to validate the nature and ethics behind transdisciplinary practices.

3a. Suggested Action: Help FOUNDATIONS, GOVERNMENT AGENCIES, AND OTHER FUNDERS develop new funding categories with regard to cross-disciplinary methods. Also FOUNDATIONS, GOVERNMENT AGENCIES, AND OTHER FUNDERS should establish new criteria for peer-panels, review, and commissions supporting these kinds of forward thinking practices.

Obstacle #4: A transparent user experience can backfire if all members of a collaboration are not actively involved.

Suggested Action: Encourage DESIGNERS, ARTISTS, and INDUSTRY to discuss the reasons behind expanding your practice/project to a more transparent platform. Is it necessary and why, and who will be responsible? Assign clear administrative roles to each member of the team. Educate ARTISTS on open share design platforms (i.e. "open ideo").

Obstacle #5: Many professionals are not exposed to trans-disciplinary practices until later in their careers.

Suggested Action: Place calls for STUDENTS and EDUCATORS to attend transcontinental residency, conferences, and programs. Encourage a core SEAD curriculum in secondary tier education.

Obstacle #6: SEAD professionals are often confronted with new and unfamiliar territory and methods of investigation, creating tension when flushing out new concept and vocabularies.

Suggested Action: STUDENTS, ARTISTS, DESIGNERS, HUMANITIES SCHOLARS, ENGINEERS be confident and mindful in the work methods you are creating. Develop simple solutions and agendas when presented with an unfamiliar area of expertise. Showcase your work for an outsider perspective. Set meeting points in your agenda to address the work as it progresses and to consider how these expectations are or are not being met.

Obstacle #8: Building and sustaining trust is a difficult task and can make or break a collaboration.

Suggested Action: That SEAD professionals and additional STUDENTS, EDUCATORS, and ADMINISTRATORS IN EDUCATIONAL INSTITUTIONS review associated methods for building trust in a collaborative environment with particular attention paid to integrity, internal confidence, and fairness.

References & Notes

1. Coburn, Calum. 2009. "Negotiation Conflict Styles." The Negotiation Experts: Create Value. http://www.negotiations.com/articles/negotiation-conflict-profiles/
2. "Collaboration: Building and Sustaining Trust." All Collaboration: Connect, Collaborate, Create, April 28. Updated December 25 2010. http://allcollaboration.com/home/2010/4/28/collaboration-building-and-sustaining-trust.html
3. Copyright & Fair Use: Stanford University Libraries. 2010. "Copyright Ownership and Transfers FAQs." http://fairuse.stanford.edu/Copyright_and_Fair_Use_Overview/chapter13/13a.html
4. Davis, Josie E. 2012. "The Success of Failure: Was it everything you hoped for?" Project Blog, Last modified August 15. http://areyoucontagious.com.
5. De Jong, Bart. 2010. "Trust and Control in Teams." PhD diss., University of Amsterdam.
6. Filler, Stephen. 2007. "Collaborating on Photographs May Create Ownership Issues." Photo Laywer: Information and News about Photography and the Law. February 14. http://nylawline.typepad.com/photolawyer/joint_authorship/
7. Illinois General Assembly. 2012. "Property (765 ILCS 1065/) Illinois Trade Secrets Act." http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2239&ChapterID=62
8. Kirshenblatt-Gimblett, Barbara. 1999. "Performance Studies." In The Performance Studies Reader, edited by Henry Bial, 43 – 51. Routledge. http://www.nyu.edu/classes/bkg/issues/rock2.htm
9. Klein, Judith Thomsen. "Prospects for transdisciplinarity." Futures 36 515-526. Accessed October 15, 2012. doi:10.1016/j.futures.2003.10.007.
10. Parker, Vicki. 2012. "Know Your Rights as a Photographer or a Subject of Photography." Hub Pages, October 18. http://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=2239&ChapterID=62
11. Richards, Catherine. 1996. "Fungal Intimacy: The Cyborg in Feminism and Media Art." In Clicking In: Hot Links to a Digital Culture, edited by Lynn Hershman Leeson, 258– 263. Seattle: Bay Press. http://www.arts.rpi.edu/public_html/century/eao12/RichardsIntimacy.pdf
12. Salter, Christopher L., Xin Wei, Sha. "SPONGE: A Case Study in Practice Based Collaborative Art Research." Creativity and Cognition 92 – 101. Accessed December 2010. doi: 10.1145/1056224.1056239.
13. Stevens, Darren. 2012. "Crowdsourcing: Pros, Cons, and More" Hongkiat.com: Design. Inspiration. Technology. http://www.hongkiat.com/blog/what-is-crowdsourcing/
14. United States Copyright Office. 2012. "Can I Use Someone Else's Work? Can Someone Else Use Mine?" Last modified July 16 2012. http://www.copyright.gov/help/faq/faq-fairuse.html
15. United States Copyright Office. 2012. "Chapter 1: Subject Matter and Scope of Copyright." Copyright Law of the United States. http://www.copyright.gov/title17/92chap1.pdf

From Workshop to Academic Laboratory, an Artistic Experience of Transdisciplinarity

Coordinator: Jean Delsaux, Visual artist, Senior associate professor, researcher at Institut Pascal (mechanics, artificial perception applied to robotics, materials for information, bio procedures, waves); Founder and codirector of Atelier Brouillard-Précis (1991-2005) workshop devoted to supporting artistic projects concerning digital technologies applied to moving and interactive images; Founder and director of LEEE Laboratory for Aestetics and space expérimentation (since 2007).

My expérience of the relations between art, science and engineering leads me to make three observations:

I consider art, science, Design and engineering at the same level, and do not insert any « / » between these entities.

I'm convinced that the main obstacle one has to overcome is the one of misunderstanding due to the fact that from one discipline to another, we may use the same words but give them a completely different meaning.

The developpement of the relations between art and sciences, engineering and design depends mainly on common projects involving equaly motivated participants, which implies that the experiment would offer the same profit for each participant.

Atelier Brouillard-Précis.

This artists workshop was founded in Marseille in 1991. I conceived it as an open workshop in connection with academic laboratories and art schools.

My previous works as an artist were related to perception, urban space, multiscreen artistic displays.

My partners were audiovisual display system manufacturers (Delcom Germany), architects, philosophers (Vilem Flüsser) and art theoriticians (Edmont Couchot), artists and developpers (Piotr Kowalski, Michel Bret, Joan Logue, Orlan, Jacques Frety, Nicolas Bus) with whom we developped at the same time a theoritical reflexion concerning art and technology.

The problem reached was the difficulty for an independant artist to maintain these links in a permanent way, and even more to establish new links with disciplines like neuro physiology of perception, robotics, mechanics etc. So I decided, along with another artist, to create a new kind of workshop in France, equiped with Unix workstations, an experimental software devoted to artistic modelization, rendering and animation, a broadcast studio for Betacam SP post production, as a basis for the development of an artistic, scientific and technological network, a

workshop where to experiment new ways of accessing the digital image, the passing from analogic to digital culture.

We first invited untrained artists and it was really an experiment to feel how these distinguished practitionners of video art or installations approached the digital, the fact that our software had no intuitive graphical developping interface, but required writing lines of code.

An artist like Gianni Toti (†) said he would never touch a keybord, but wanted us to provide « the all of the machine », that is, to exhibit the total content of the graphic computer, he exhausted three junior developpers really amazed by his demands. There was a powerful experiment for these master students to analyse the content of a computer and to have to try and explain him how the machine would work, as well as to get from this « poetronic » artist, informations about his conception of art and creation, the twists he permanently provoqued within the logical procedures.

The point was that we could experiment with the artists the paradigm change related to the representation of space, their perplexity facing this strange « virtual » space.
We had in that purpose to give them a previous training so that they could understand at least what was going on. Then the training was continued along the creation process.
Joan Logue asked us to modelize a golden frame she had photographed in the Louvre (Paris), at every stage of the modelizing and rendering process, she needed to see what she called « the real frame », while on another machine the line tests of animation were tried in wireframe.
Photographer rand videographer, she was not used to anticipate the results in this way, of course in the early nineties, the computing time of an image was quite long, 25 frames for one second lasted sometimes one day, and we could not afford to make movement tests with rendered images.

We experimented the phenomenology of perception and behaviors within the space along with artists that freshly discovered it. This was the reason for us to develop our links with neuro and psycho cognitive sciences.

Nevertheless, Orlan had the opportunity to work with a young engineer who had developped a morphing software and they created images resulting of morphing between herself and reproduction of the female archetypes she had choosen in art history.
We had first to realize snapshots, that is still frames of her reproducing the lighting and the point of view of the different paintings. Realizing this kind of analogic simulation was possible because we were trained as artists, we could then digitize and experiment immediately in the morphing process, thanks to the disposal we had set up.

Then she explained to the engineer that she was really interested in the missmatches occuring during the morphing process. Effectively, this artist who transformed her face and body by cosmetic surgery, according the paintings, wanted to underline the fact that cosmetic surgery exposes the subject to unexpected failures and she wanted to compare the selfportrait made on the body-machine and the one made by the computing machine.

The young developper was first really ashamed to show pictures he considered as technical mistakes, but later on, during the collaboration process , he understood the concept and was afterwords the best engineer we could work with.

The experiment was really exiting and full of results, but the difficulties were really too important for the invited untrained artists, and therefore for us.

We decided then to invite artists aware of the digital technologies, mainly programming various disposals.

It seems important, as far as art and research are concerned, to consider separately the training and the practice, even if the training should be refered to a practice, so that the practice should not be delayed by the necessities of learning new logics, environments, approching a new culture.

Suggested action 1

Universities should open sections devoted to the transdisciplinary training organizing a link between the artistic culture, humanities, and scientific and technological culture. The so trained students could then perform the synthesis betwween the modusses operandi, different cultures and thus enable a cultural confrontation.
The purpose is not to train absolutely only people able to be performative in both fields but people who specialise themselves in a discipline and are able to collaborate with other specialists.

These sections have of course to be provided with spaces (workshops) and technical equipment, technical support and maintainance, artistic and scientific environment.
The second phase of our experiment, which involved artists aware of digital technologies and scientific culture, reached also a difficulty : one person cannot master the complete set of abilities and knowledges required in an art process concerned by science and techniques.

The various projects we developped involved the participation of various participants, each one mastering a particuliar know how.
The problem then was to be able to build the appropriate crew for the concerned project.

Suggested action 2

In a structure devoted to the development of SEAD projects, there should be a person whose ability would be to analyse the project and determine the appropriate crew to fulfil the project.

The second difficulty we had to overcome was then to enable everyone in the crew to understand the language of the other participants. Speaking about spaciality for example is really different whether you are a visual artist, a musician, a physician, a mathematician, an engineer, an architect etc.

Suggested action 3

The development in universities, art schools and engineering schools of transdisciplinary subjects involving this aspect of mutual understanding. This point is different from **suggested action 1** as it emphathize the language problem, the theoritical aspect, the understanding, and not necessarily the development of procedures, projects, realizations.

LEEE (Laboratory for Aesthetics and Space Experimentations) **and Institut Pascal**(Laboratory of robotics and artificial vision).

Colleagues with whom I developed other initiatives more precisely involved in this field suggested also a convergent approach of the matter:

Pascale Weber, Multimedia artist and Senior Lecturer in visual arts (University of Paris 1 Panthéon-Sorbonne) developped in a book we directed accordingly : De l'Espace virtuel, du corps en présence[1]. (Presses Universitaires de Nancy Ed.) an interesting experiment concerning the development of a collaborative platform devoted to SEAD projects and the reasons of its failure.

The artists we were needed a collaborative platform devoted to our crossed projects, so we decided to develop it along with colleagues computer scientists.

The point was that artists are trained to metaphorical language, developping projects by experimenting the results of the trial-and-essay method. And we wanted to conceive the platform alternating an experimental and a more theoritical approach.

That is:
Experimental: creation of spaces, templates, simulated digital functionings, for the projection of the artist taking part, from the development of the tool to a well tried praxis of the platform. The artist is used to work through sensitive equivalents so as to widen futhermore its metalanguage.

Theoritical approach: definition of the technical specifications of the platform.

This way of doing is far from what developpers we worked with were used to : they usualy start with specifications, in order to face a clearly defined request. The question is then to decide wether the artist/user should describe his needs in technological and « rational » terms for the developper or if the developper should analyse himself the request and translate it in his own language.

Another way of doing would be to let the user describe his needs progressively and continuously, avoiding permanent redirectings (in a flexible and not fixed way).
Very often the request is perfectly defined but doesnt suit the technological procedures.

Suggested action 4

The solution would probably consist in organizing, all along the project development, systematic meeting times during which would be defined the constraints for the artist and instructions for the computer scientist.

The difficulty is obvious and leads usualy developpers to conceive generic models one has later on to adapt to the needs of the user. Which implies a predominance and primacy of the computing models and a definition of the digital products not in term of of specific needs, but in term of qualifying options.

This has to be connected by the increasing power of hardware and software companies who impose their standards, their monopolistic domination over systems and software packages.

The open source philosphy is in that purpose a good answer, but we know also that it requires yet a sophisticated know-how as well. And above all, no matter the models can be, technology seems allways to be set first, needs and specific expectations being considered as seconds, functionality creating the need.

So even if this situation is specific and not exclusive of other configurations, it is widely represented.

Suggested action 5

Build teams that would elaborate new procedures, new relationships between members, whatever would be the expertise of each member. These teams should have time and ressources to fulfil their goals : developping tools, situations, procedures involving artists, computer scientists, ergonomists, neurocogniticians, engineers, …

This implies budget, long term research, hability of defining the program in complete autonomy.

The development of a project can also work out its own tools, a projet can exist as a drawing, a draft, an animation, a métaphor, a choreography, a picture book, a textual description.

Thierry Château, Professor of robotics and computer vision leads the ComSee research team at Pascal Institute (Ex. Lasmea). Main research interests : Visual Tracking, Pattern Recognition and machine learning, within the field of Computer Vision.

For Thierry Château, the problematics raised by the artists allow almost to be early of phase with the Industry. The experience the lab had with dancers raised with an unsual accuracy the problem of latency. Artist are really sensitive to the delay due to latency (response time of interactive devices). A practicle application was that after working with dancers who had particuliar requisits about latency, the developpers could propose an interresting tool to EDF (french company providing electicity) for the training of emmployees working inside nuclear stations.

So one can capitalise the acquired experience.

The other advantage for a researcher is the determination of new research fields due to the artists' expectations and requests. Artists says T. Château have a different approach and imply for the computer scientist to look at things under a new light.

The « Institut Pascal welcomes two artists and one ergonomist in its teams to develop projects embeded in its research program.

This opportunity values the suggested action n°3

I also had a very interesting collaboration with Delcom Company (Germany) in the eighties, this company producing dynamic digital videowall systems invited artists to perform on its product. They said that « artists are the Formula 1 of our system, they raise problems we have to solve, which leads us to improve our system. Artist imagine situations we didn't anticipate, they propose other ways of using the devices we produce. »

Suggested action 6

Organize meetings, seminars involving major or local industrials, in order to developp with the support of ministry, local administration, chamber of commerce, the commitments of the industrial and financial sectors to transdisciplinary projects.

In these sessions, each participant (provider, scientist, artist, engineer…) could propose his own research project. Then these projects, specificaly defined by a person, would be in turn rephrased by others. So within this appropriation logic, the exchange could really begin.

Interdisciplinary Courses, Positions, PhD, in Italy

http://wp.me/P2oVig-js

Coordinator: Michele Emmer, Dipartimento di Matematica, Università di Roma "La Sapienza"

The paper elaborates on my experience with interdisciplinary courses between mathematics and a number of subjects (art, architecture,...) over a number of years and discuss some difficulties that have arisen and a few proposal for actions. Some of these themes are general by nature, as well as some of the actions that can be undertaken.

First of all I would like to say that these academic activities started as a personal experience more than 30 years ago. For many years I was (and I still am) officially a full professor in Math and non-officially I worked on the relationships between mathematics, art, architecture, biology, physics, literature, cinema. At a certain point of my activity my work on art and math was recognized as official work in mathematics.

Introduction

"Changes in education are not going to produce miracles. The division of our culture is making us more obtuse than we need be: … we are not going to turn out men and women who understand as much of our world as Piero della Francesca did of his, or Pascal, or Goethe. With good fortune, however, we can educate a large proportion of our better minds so that they are not ignorant of imaginative experience, both in the arts and in science."

On October 6th 1956 an article by Charles Percy Snow was published on the New Statesman that discussed a problem that would have been developed in a lecture and a book three years later. The book, entitled The Two Cultures [1] compared the scientific and humanistic culture, particularly in the Great Britain of that time. The book sparked a long polemic that moved Snow a few years later, in 1963, to publish an appendix to the book that concluded with the words quoted at the beginning. Snow was a chemist who had the misfortune in 1932 to mistake the data in an experiment. The episode determined the end of its scientific career. He became a writer. His novels were published in different countries between 1940 and 1970. With the book The two cultures he became famous all over the world.

In the introduction to the 1993 edition Stefan Collini, professor of English literature at the University in Cambridge wrote: "We need to encourage the growth of the intellectual equivalent of bilingualism, a capacity not only to excercise the language of our respective specialism, but also to attend to, to learn from, and eventually contribute to, wider cultural conversations." In short we are speaking of interdisciplinarity.

In 1981 the USA art historian Linda D. Henderson published a book destined to change the way in which we look at modern art all the way through, to the artistic avant-garde of the twentieth century "The Fourth Dimension and Not Euclidean Geometry in Modern Art" [2]. The research still continues, (the second edition of the book will be published in 2012, with 200 additional pages, MIT Press). Linda Henderson reconstructed the ways through which the new ideas of

geometry of the second half of nineteenth century, particularly non Euclidean geometries and the idea of the fourth dimension, (before the theory of the relativity and the space-time), have influenced the art of the XXth Century, including through the literature inspired in mathematical research, in particular the novel Flatland of Edwin Abbott, published in 1884. [3]

Linda Henderson used almost the entire scientific and mathematical researches of the period. She obviously does not affirm that these were the only sources of inspiration for the artists. She identifies complex and fascinating Arianna's threads that form new ideas in science and in art.

In 1982 I realized with Linda Henderson one of my films of the series Art and Mathematics. [4] Since then we have collaborated in different conferences and in the project of a large exhibition on Mathematics, Modern and Contemporary Art. It is not clear if the exhibition will be realized due to Italy's financial problems.

In the same years I discovered the Journal Leonardo and I started a collaboration on art and science that is still ongoing. I have had the great pleasure of being in the board together with Max Bill, one of the great artists of the XXth Century, with whom I realized two films of the series Art and mathematics. [5]

The situation in Italy

After many years in 2012 a huge operation of evaluation of Italian Universities, professors and researchers took place. Around 50.000 people and hundreds of thousand of articles and scientific books are being appraised. The magic answer to this problem was finally found. If numerical objective indicators existed, numerical (and what can be more objective than numbers!) to identify best candidates, the problem would be solved. These indicators have existed for a few years. They serve to measure the number of published articles, the quality of the journals in which they are published (international journals obviously), the number of citations of the articles showing the interest and the seriousness of the researches.

The ANVUR, the National Agency for the Evaluation of the Research was created. Scopus indicators of the publishing house Elsevier and those of Web of Science of Thomson Reuters ere chosen, with all the problems of objectivity that these choices involve. It is important to clarify that these indicators work only for the scientific sectors, for the humanistic and artistic sectors, they don't exist. Then the way to appraise had to be divided in two. Selected journals were selected for the non-scientific sectors, sectors in which obviously the published books are considered essential to appraise in this discipline. Some of these journals were really peculiar and not really scientific, their titles were even published in the Italian newspapers. So the scientific researches have they the indexes, the not scientific have theirs peculiar methods. And more, scientific evaluation methods based on h-index or similar do not exist for books.

The criteria adopted in Italy (index, etc.) create some problems. All those areas that are and want to be interdisciplinary are virtually eliminated. Would the books of Linda Henderson and Snow be taken into consideration? In which sector? For example, historians of mathematics as mathematicians are in the scientific sector but they edit and write books and therefore are not considered by the humanistic criteria of evaluation, nor by the scientific ones since books are nor

considered. So forget to study art and science! This is the general situation in Italian universities. And so it is impossible to ask any young researchers to take courses that are interdisciplinary in nature. There is no future for them.

Some positive signs

I was very proud when I received as national coordinator two grants in 2007 and 2009 (the rules exclude applying for a grant every year) for research on mathematics and modern art. These grants were assigned by the Italian Committee for National Funds (PRIN) for mathematics. So the math researchers decided to support my research on art and math. Due to the economic crisis in Italy and in the funds for the Universities a choice like this means that other research, strictly math research, did not receive a grant. This was unthinkable 30 years ago, even 20 years ago.

Due to the change in the attitude of the Math community it was possible to undertake several projects:

Conferences and books

The "Mathematics and Culture"[6] international yearly conference in Venice starting in 1998. Part of the conference is dedicated to art and math. Proceedings in Italian and in English by Springer verlag, more than 25 volumes. From 2012 a new series "Imagine Math: math and culture" [7] always published by Springer verlag. The next conference in 2013 will be particularly interesting because speakers will include Linda D. Henderson on a project for an important exhibition on art and math in Italy.

The series of books "The Visual Mind: Art and Mathematics", [8] published as Leonardo books by MIT Press, the first in 1993, the second in 2004, with several editions.

Exhibitions

A first traveling exhibition in Bologna, Parma, Milano and Rome on "The Eye of Horus: itinerari nell'immaginario matematico" in cooperation with the Istituto Italiano of the Enciclopedia Italiana, the Istituto di Studi Filosofici of Napoli and the Citè des Science de la Villette de Paris, in 1989/99.

A session of the Biennale of Art in Venice in 1986 dedicated to the theme of Art and Science. Including a part on art and mathematics.

Smaller exhibitions related to art and science and the annual meeting in Venice with artist like Peter Greenaway, Achille Perilli, George Hart, Heleman Ferguson, Bradley Miller and others.

A large project of an exhibition on Mathematics and Modern and contemporary Art, to take place in novemebr 2012, postponed due to financial problems.

Films

20 films of the series "Art and Mathematics" [9] produced in several languages, shown in the Italian State Television and other TV channels, including the film on Soap Bubbles, featuring the well known mathematicians at Princeton University Fred Almgren and Jean Taylor.
A film on Escher with Roger Penrose and Donald Coxeter, distributed in USA for 20 years, a film based on the book Flatland all in animation, original music by Ennio Morricone. All films were produced in French for the Citè des Sciences de la Villette in Paris. Most of the films produced also in English and Spanish versions.

Courses at the University

In 2004 I launched a completely new course, existing only at the University of Rome, called "Space and Form", [10] an interdisciplinary insight of the relationships between mathematics, art, architecture, biology, literature, theatre, cinema with a myriad of applications in all these fields during the XIX and XX century. It involves students of the last years in math, design and architecture, including a small group of ERASMUS students from several European Countries.

The number of students is usually every year between 50 and 60, adding to more than 450 in seven years. There is a project to write in English a text book of the course to be used of course not only in Italy, but I hope in Europe and elsewhere.
Soap bubbles are part of the topics of the course on "Space and form". There is the project to publish an English version of the book.
Architects, Like Massimiliano Fuksas, artists, writers, filmmakers like Gustavo Mosquera, came to present their works to the students for the course "Space and Form"

One important result of this activity was:
- The Literary Viareggio Award 2010 (Best Italian essay 2010) for the book on "Soap Bubbles" I wrote in Italian. The same year the International Viareggio Award was given to Vargas Llosa. A short abstract of the motivation of the Jury, most of them university professors):

 "Emmer wrote an extraordinary book in which mathematics and science, analytical rigor and artistic sensibility is a perfect match, …a real adventure of intelligence, which he reconstructs in masterly fashion by giving us a book not only interesting, but rare."
The same book also received the Premio Capalbio Scienza 2010 (Best science book)

The real problem

There is an interesting discussion developing in Italy and Europe on the possibility to introduce interdisciplinary curriculum, master, PhD in art and science. The real problem is to obtain positions for researchers in this area. In Italy in particular there is a major problem: in which discipline can we insert an interdisciplinary course? Can you ask a math department for a position for a young researcher on art, math and architecture? In Italy it is impossible for the time being. As it is impossible to obtain any dedicated PhD program or any contract for lectures. I cannot recommend my students to continue to study art, math, architecture, as there will be no future for them.

At a European level however, there is a new PhD in France and Switzerland on art and science for artists and designers, as well as interdisciplinary seminars on art and science proposed for 2013 in Paris. While at the European level it is possible to ask a grant to organize an exhibition on art and math this is out of the question in Italy.

In 2008 we started an important project of a large exhibition on math and modern and contemporary art to make visible all the work that has been done in the last years. This year there was the exhibition on art and math at the Cartier Foundation in Paris (nor really satisfactory) and the small exhibition on Henry Moore and math at the Royal Society in London. This exhibition will probably move to Venice in 2013.

Suggestions and actions

I can suggest the following actions:

Action #1: Web site and Visibility

I agree with the proposed Action #1 of K. Evans [11] that cross-disciplinary art- science humanities researchers are isolated and have no knowledge of what is going on in the world. So the first thing is to create a well done website so to maximize the diffusion of all possible information's, on interdisciplinary courses, masters, degrees, on the curricula, on books (with possible reviews), articles, journals, conferences, meetings, novels, films, plays in theatre.

It will be essential to have a website where it is possible to exchange ideas, experiences.

Action #2: exchange of experience

To encourage the exchange of professors and students to participate in interdisciplinary experiences in different countries. It is clear that it is easier among European countries using the program ERASMUS, more complicated between Europe and non-European states for obvious reasons of cost. In the website an essential part must be dedicated to all possible opportunities of exchange of professors and students.

Action #3 promote new interdisciplinary researches

To use Leonardo and a new website for suggestions for new interdisciplinary courses and researches. I believe that the contact between different universities and research teams in order to obtain funds from ESF (European Science Foundation) and similar institutions in other countries is essential. A program of research to be presented by researchers and artists who are linked to the network of Leonardo for proposals for new research and exhibitions to be presented in conjunction with the European community, the NSF and other similar bodies.

Interdisciplinary projects that will lead to the realization of exhibitions, interdisciplinary conferences, screenings of films that have interdisciplinary interest to motivate younger students to learn in an interdisciplinary way.

Ask all researchers and artists involved in the SEAD to start a formal request to initiate exchanges of students and researchers for short periods. With regard to mathematics and art, there are various associations, various annual conferences, that can be contacted.

Action #4 new book series

Start creating interdisciplinary series of publications not only at a research level but also for graduate and undergraduate courses. Not only the Leonardo book series. For mathematics and art and architecture there are already the series by Springer verlag "Mathematics and Culture", "Imagine Math", and by Birkhäuser "Mathematics and architecture"

Final comments

Due to my personal experience and my knowledge it will be easier to organize interdisciplinary courses, masters, perhaps PhD, at the European level. It will be probably easy if the different European countries put their experience together to ask for an international and interdisciplinary important Grant for the next years. It will be probably more complicated to cooperate also with USA. But Leonardo is a good way to cooperate.

References

[1] C. P. Snow, The Two Cultures, Cambridge University Press, Cambridge, 1993.
[2] L. D. Henderson, The Fourth Dimesion and non Euclidean geometry in Modern Art, Princeton University Press, 1981; second ed. MIT Press, to be published.
[3] E. A. Abbott, Flatland, London, 1884; M.Emmer, ed, Flatland, Italian & English, with DVD of the film by M. Emmer, Bollati Boringhieri, Torino, 2008.
[4] M. Emmer, film maker, Dimensions, series Art and Mathematics, DVD, 25 m., english, french, italian. Prod. Film 7 International & M. Emmer, Rome.
[5] M. Emmer, film maker, Moebius Band, Ars Combinatoria, series Art and Mathematics, DVD, each 25 m., english, french, italian, spanish. Prod. Film 7 International & M. Emmer, Rome.
[6] M. Emmer, ed. Mathematics and Culture, volume I, II, III, IV, V, VI, Springer verlag, Heidelberg, 2005- 2012. Italian version Matematica e cultura, Springer Italia, Milano, 14 volumes, 1998-2011. Website of the annual congress: http://www.mat.uniroma1.it/venezia2013
[7] M. Emmer, ed. Imagine Math, Sprigner verlag, Milano, 2012. Imagine Math 2, to appear march 2013.
[8] M. Emmer, ed. The Visual Mind, MIT Press, Boston, 1993; The Visual Mind 2, MIT Press, Boston , 2004.
[9] M. Emmer, film maker, series Art and Mathematics, 18 films in DVD, each 25 m., english, french, italian, spanish. Prod. Film 7 International & M. Emmer, Rome.
[10] http://www.mat.uniroma1.it/people/emmer
[11] K. Evans, Breaking down the Silos: curriculum development as a tool for crossing disciplines in the arts, sciences and humanities, SEAD white paper, preprint.

Between Barriers and Prospects: Merging Art Performance and Engineering in Mobile Music Education and Research

http://wp.me/P2oVig-ni

Coordinator: Georg Essl, University of Michigan

1. Introduction

There is little doubt that mobile smart devices are a socio-cultural game changer. The reach of sophisticated, networked, interactive computational technology will soon be universal. This means that technology with tremendous capabilities for artistic expression open up a space of exploration for new forms of culture and creativity.

The mobile phone has become the most widely distributed, accessible communication and computing device. In 2010, the mobile subscription base has reached an estimated 5 billion and the penetration of these devices in North America, Europe and Japan is considered to have reached 100% but sales are still growing due to the drastic improvements in mobile smart phone technology (Wingfield 2009). The mobile phone is no longer just a portable version of the classical telephone, but has become a device serving a large set of diverse needs. It is a digital camera, a media consumption device ranging from e-book reader, to music and video player, to portable TV and gaming platform. It serves as personal data organizer, Internet client, navigator through GPS integration, and increasingly as a general-purpose computing device. Given the high density of sensor technologies, such as integrating accelerometers, gyroscopes, magnetic field sensors, microphones and cameras, mobile devices offer a new sensor environment that additionally is highly mobile, making the platform significantly different to desktop computing. The exploding ubiquity of these devices will make new forms of artistic and collaborative activities possible that are much harder to envision with desktop systems that need to be used in static settings.

Mark Weiser's prediction of a "ubiquitous computing" world (Weiser 1991) is becoming true through mobile technology. The size of the device means that it is often carried like a wallet. This in turn means that the computational capacity of the device moves with its owner and computational capacity scales with number number of members in the group who brought their personal device. The mobile phone is the new personal computer, re-spawned in a new environment where connectivity is a constant, participation is growing at a rapid pace, and the support of content creation becomes ever more important.
Over the last five years we have seen an explosion of user generated content (Dawson 2008) on sites like Flickr, YouTube, Facebook and blogs. Especially teenagers are now confident and frequent users of the Internet. In 2007 about 93% of teenagers in the US used the Internet, but more importantly already in 59% participated in some form of digital content creation and sharing (Lenhart et al 2007). Internet access through mobile devices is growing drastically and

data traffic has already surpassed voice traffic in 2010 and is expected to dominate traffic volumes in the future (Thomas 2007).

2. Prospects and Barriers of Mobile Technology for Creativity and Participation

This means that an unprecedented opportunity for participation in creative endeavors mediated through commodity computing devices is emerging and a tremendous impact on communities who have as yet find participating in the digital culture. Due to the mobile nature of the device, the ability to participate will drastically increase, as well as change where participation can and will happen. Hence we should expect to not only see drastic changes in the demographics of participation, but also the general character of the participation itself.

Currently we face a barrier of access for most users of mobile technology due to the complexity and sophistication of the devices and the depth of domain knowledge required to build creative applications on them. Typical users of smart devices are not trained engineers, nor necessarily trained performance artists.

Mobile devices also have already shown to be vehicles for diminishing, perhaps overcoming, the various domains of separation of access and literacy in information and computational technologies (ICTs) called the Digital Divide. Difference in access and participation can be seen along many dimensions, including geography, age, gender, socio-economic status and ethnicity (Hargittai 2003). Mobile devices are significantly cheaper and by serving multiple needs such as communication and computation at the same time, often more viable. Mobile devices tend to see diminished use segregation by gender and by socio-economic group that we observe with classical computational platform, and underrepresented minority show a disproportionally large segment in mobile internet use (Brown et al 2011).
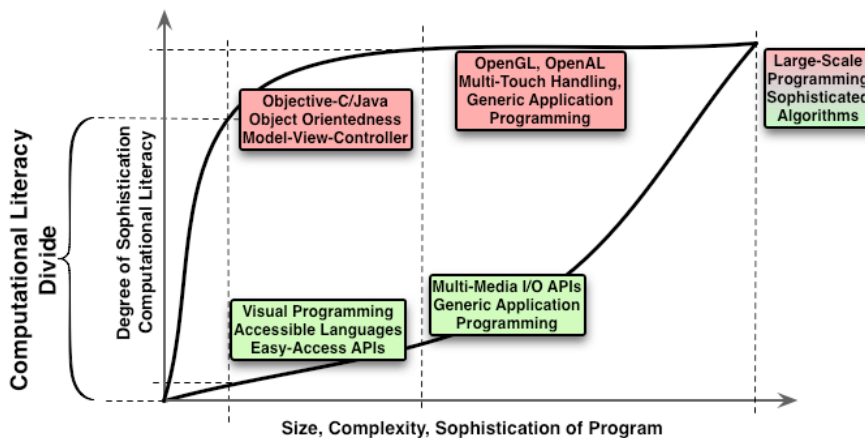

Figure 1 The progression of computational literacy for mobile programming today (top curve) versus the kind of literacy progression that is desirable for broad participation (bottom)

So far industry focuses on media consumption, rather than broader participation on digital content creation and computational literacy. For example Apple has removed academic

computational literacy projects such as Scratch from their mobile AppStore to ensure a policy that all programming happens through Apple-controlled pathways (Chen 2010). Current mobile platforms are not optimized for easy programming. Level of entry for participation on the process is high and requires low level programming knowledge, heterogeneous hardware setups such as a laptop, USB cable connectivity and large screen IDEs such as Xcode for iPhones or Eclipse for Android. This requires high levels of training and knowledge. It also imposes an additional financial burden, by requiring additionally substantially more expensive hardware (such as a laptop) for the programming activity.

This leads to a kind of Computational Literacy Barrier, as illustrated in Figure 1, separating those who had substantial preparation and resources to acquire it away from mobile technology, from those who have access to mobile technology but limited alternative means, opportunities or interest to acquire literacy elsewhere.

However, it has been widely argued that computational literacy is important in a world immersed in ICTs (Nelson 1974, diSessa 2001) and we see it as critical to create pathways mobile technology users to learn, create, and participate.

3. Research Challenges

Mobile smart devices are also shifting various technological paradigms. Creative content creation on laptop and desktop computers assumed a given interaction model centered around keyboard, large monitor, and mouse. A multi-touch centric device with a small display and additional rich input sensors such as cameras and motion sensors replaces this. A further significantly changed factor is the size of the device which can be substantially smaller than other general purpose computing devices.

Hence existing models for supporting computational creativity have to be rethought and we need sustained research to develop fitting models of Human-Computer Interaction that solves key problems in creativity support and content creation, and allows accessibility for as wide a target audience as possible.

Central questions that are persistent research topics include:

1. The evolution of hardware for expressiveness. Commodity devices in creative expression form a delineating canvas of the possible. This means that a concern for expressivity will mean a continued evolution of hardware. For example current mobile multi-touch technology tends to not support pressure sensing or tactile feedback, yet these are important factors in fine motor control.

2. The development of programming and content creation paradigm that fit the input and output modalities of the form factor of commodity mobile devices. This may well require a re-envisioning of the very basis of programming as no longer a necessarily textual paradigm, but one that is constructivist or symbolic.

3. Design for universal accessibility in order to reach diverse target audiences.

4. Design for on-line interactive and performative use.

To this end we develop an environment called urMus, which seeks to provide a mobile-centric design of open, and accessible creativity support. However we do see our individual effort as but one proposal to offer technological solutions to key questions of participating and we suggest a broad range of engagement with the field.

4. Mobile Technology in Interdisciplinary SEAD Teaching

We designed a senior level undergraduate course titled "Mobile Phones as Musical Instruments." It is cross-listed between the College of Engineering and the School of Music, Theater and Dance at the University of Michigan. The placement of such interdisciplinary course has numerous challenges but also clear benefits. The course is designed to blend students from diverse preparatory backgrounds. All students engage in the full range of activities in the course without distinguishing if they pursue education in engineering or the arts. We discuss describe advantages and pitfalls of this course design. UrMus is the central programming platform in our course. Its design allows rapid access, early rewards, and a sense of mastery. As students become more proficient the design allows deep engagement and open expression. An exit surveys show that students largely see the approach as successful, independent of prior background.

Mobile smart devices have already had a drastic impact on how we use computation and expanded who is able to participate. The prospect of enabling broad participation on technological creativity is tremendous with potential impact on who can enter STEM and creative fields.

4.1 Evaluation of Cross-Disciplinary Teaching of Art and Mobile Technology

In Fall 2010 the course "Designing Mobile Phone Musical Instruments for Ensemble Performance" co-listed in Electrical Engineering & Computer Science in the College of Engineering as well as Performance Art Technology in the School of Music, Theater & Dance was funded by the College of Engineering Curriculum Innovation program.

The course is inherently multi-disciplinary engaging students in both music and engineering practices. The primary goal of the course is open-ended problem solving and creative engagement with a clear final outcome. The course asks students to design their own mobile phone musical instruments, conceptualize and write music for it and ultimately perform the results in a live concert, which is open to the public. Here we report the outcome of such a SEAD course.

The course has two main of challenges:

1) Integration of a very diverse set of student preparations and experience in an upper level course bridging two colleges.

2) Innovating technological teaching with emerging new platforms such as commodity mobile smart devices.

There are also a number of further challenges such as the reality of proprietary mobile phone programming. Hence it was important to find ways to allow the students to go beyond a limited set of devices or specific form factors.

For the first time students were allowed to loan devices for the duration of the course hence were able to work on assignments on the device on their preferred schedule. The learning curve of programming was adjusted to be platform independent and use a high-level programming language. This addressed two concerns of the first iteration of the course. One was a learning curve that was too challenging for many Performance Arts Technology majors, as it required rapid learning of Objective-C from the start. Second was the ability to postpone hardware specific details to the end of the course and focus the teaching efforts on principles that are not specific to one platform or form factor.

4.1.1 Assessment

In order to assess the innovations introduced to the course we conducted an informal survey asking questions specific to the curricular changes and their benefits as well as broader questions about the reception of the course using a 5-point Likert scale. The questions were fully anonymous and participation was voluntary. Six students chose to answer the survey. One of the six students omitted the questions of the second page (Q9-11). The survey questions are attached at the end of the report.

The questions were designed to address the following questions: Did introducing access to hardware help the course in the student's mind (Question 2, Question 11)? Did the learning curve adjustment work (Questions 3-5)? Does the cross-disciplinary integration work in the eyes of the students and stimulate curiosity (Question 1, Question 7-10)?
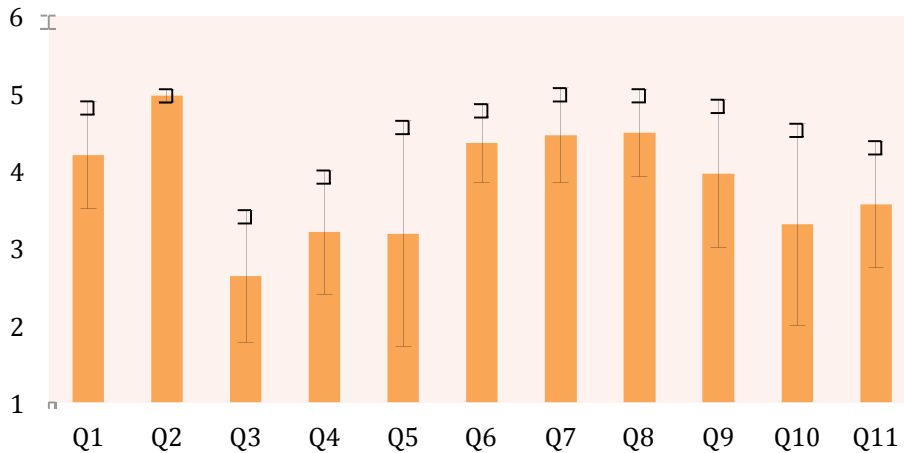
Survey Question Scores

Figure 2 Mean and standard deviation of answers to course survey questions.

The mean answers to the questions can be seen in Figure 1. The most direct measure of the devices on loan being helpful is Q2 which was answered very positively by all students (avg=4.97, stdv=0.08) however students were less clear if this was essential (Q11, avg=3.56, stdv=0.8). Students felt that the cross-disciplinary integration was positive (combined score of Q1, Q7-Q10, avg=4.08, stdv=0.48) and that they learned many aspects of the subject matter (Q6, avg=4.2, stdv=0.69). Question about the learning curve (Q3-5) have a combined score of avg=3.01 with a relatively large deviation (stdv=1.04). This is likely an indication of the bi-modal distribution of prior experience of students in the class. The fact that the mean is at neutral is a good sign, indicating that a balanced between the two populations was nevertheless possible.

All these results have to be taken with care because of the small sample size (N=6) and possible other uncontrolled biases.

4.1.2 Other outcomes

The course has a public concert of student pieces as final. Thanks to the new diversity of devices the repertoire and style of pieces was greatly expanded and specifically the engagement with different form factors (iPad vs iPod Touch) clearly is visible. Overall the student projects had more depth and detail thanks to the improved learning curve and the added time to deal with more detailed issues such as graphics rendering, projection and networking.

The full pieces can be found on the YouTube channel of the department of Electrical Engineering and Computer Science of the University of Michigan.

Figure 3 Impressions of the final concert outcomes of the cross-disciplinary course "Designing Mobile Phone Musical Instruments for Ensemble Performance" at the University of Michigan

4.1.3 Sustainability

The original course of Fall 09 has seen drastic changes in its design and use of technology. The primary change is in the software environment that is used. We have developed a platform called urMus, which is meant to support mobile development with an abstraction of the hardware layer. This means that changes in future hardware and differences in hardware available can be mitigated. The control over learning difficulty in the environment is a major factor of allowing a proper retuning of the learning curve of the course. Overall urMus allows a range of mobile programming and technology related courses to be taught in a platform independent matter and should translate into other settings as well.

A broader lesson learned is that on-device learning with new technology is possible, while retaining scalability when proper support software is developed to achieve hardware abstraction. Students benefit from being able to interact with emerging technologies for their assignments by loaning the devices for assignments and projects and content can be presented in a more compact yet still accessible fashion. The main obstacle of using the devices the student own is platform heterogeneity and the lack of flexible cross-platform support.

5. Socio-Cultural Impact and Challenges

Mobile technology already shows tremendous socio-cultural impact. The permanent availability of computation, networking and connectivity restructures access and participation. However there are also emerging roadblocks in the way important stakeholders in industry to shape the marketplace and commodification of mobile content. In particular mobile platforms can be rather closed and are designed around a consumer-centric model of content delivery. Even computational content in form of apps are delivered like other consumer media, such as music, video, or books through online marketplaces such as the Apple AppStore. However industry is still establishing the standards and different companies take different approaches. Also access

and delivery models such as web-based interactive content may change access barriers that current delivery models to have.

6. Suggested Actions

Obstacle 1: Heterogeneity and closedness of commodity platforms that are suitable for open creative expression in the marketplace.

Suggested Action 1: Advocacy with mobile platform industry to offer openness and free content creation on their devices along with efforts to standardize or support cross-platform content exchange.

Obstacle 2: Lacking unified forum for open exchange and archival access of SEAD art and products.

Suggested Action 2: Efforts for creating open access archival platforms for SEAD mobile art products that may or may not be commodified. In particular library function should be extended to allow for the archiving and delivery of interactive and performative content, which could be in the form of apps or dynamic online content.

Obstacle 3: Academic participation in shaping the mobile platform space to allow open innovation for SEAD research and artistic engagement.

Suggested Action 3: Develop funding initiatives with NSF that target the mobile platform and foster research that create acceleration of SEAD in broad public use.

7. References

Brown, Katie; Campbell, Scott W.; Ling, Rich. (2011). "Mobile Phones Bridging the Digital Divide for Teens in the US?." Future Internet 3, no. 2: 144-158.Butts, L.,Cockburn, A. (2002). An evaluation of mobile phone text input methods. Aust. Comput. Sci. Commun., 24(4):55–59.

Cennamo, K.. & Vernon, M. (2008). Fostering Creativity in the Classroom: A Case Study of a Multidisciplinary Design Project. Invited paper presented at "Success factors in fostering creativity in IT research and education", Arizona State University, January 18-20, 2008, workshop sponsored by the National Science Foundation.

Chen, B. X. (2010). Apple Rejects Kid-Friendly Programming App, Wired, April 20, http://www.wired.com/gadgetlab/2010/04/apple-scratch-app/

Dawson, R. (2008) Future of Media Report , July, http://futureexploration.net/images/Future_of_Media_Report2008.pdf

de Paula, R., Fischer, G. and Ostwald, J. (2001). Courses as Seeds: Expectations and Realities. In P. Dillenbourg, A. Eurelings and K. Hakkarainen (Ed.), Proceedings of Euro-CSCL' 2001, Maastricht, Netherlands, pp. 494-501.

diSessa, A. (2001). Changing Minds: Computers, Learning, and Literacy. Cambridge: The MIT Press.

Essl, G. (2003b). "On Gender in New Music Interface Technology," Organised Sound, 8:1, 19-30.

Essl, G. (2010). UrSound - Live Patching of Audio and Multimedia using a Multi-Rate Normed Single-Stream Data-flow Engine. In Proceedings of the International Computer Music Conference (ICMC), Stony Brooks/New York, June 1-5.

Essl, G., Rohs, M. (2009). Interactivity for Mobile Music Making. Organised Sound 14(2) 197-207.

Essl, G., Wang, G., Rohs, M. (2008). Developments and Challenges turning Mobile Phones into Generic Music Performance Platforms. In Proceedings of the Mobile Music Workshop, Vienna.

Essl, G. (2010a). Mobile phones as programming platforms. In Proceedings of the Pervasive Workshop on Programming Methods for Mobile and Pervasive Systems, Helsinki.

Essl, G. (2010b). UrMus – An Environment for Mobile Instrument Design and Performance, In Proceedings of the International Computer Music Conference (ICMC), Stony Brooks/New York, June 1-5.

Essl, G. and Müller, A. (2010). Designing Mobile Musical Instruments and Environments with urMus, In Proceedings of the International Conference on New Interfaces for Musical Expression (NIME), Sydney, Australia, June 15-18.

Hargittai, E. (2003). The Digital Divide and What to Do About It. New Economy Handbook, D. C. Jones, ed., San Diego, CA: Academic Press. 822-841.

Hazas, M., Scott, J. and Krumm, J. (2004). "Location-Aware Computing Comes of Age", IEEE Computer Magazine, vol. 37, no. 2, February, pp. 95-97.

Hewett, T.,(2005). Informing the Design of Computer-Based Environments to Support Creativity, International Journal of Human-Computer Studies 63, 4-5, Special Issue on Computer Support for Creativity, E. Edmonds, L. Candy (Eds.), pp. 383-409.

Johnston, W. M. , Hanna, J. R. P. , Millar, R. J. (2004). Advances in dataflow programming languages. ACM Comput. Surv., 36(1):1–34.

Lenhart, A., Madden, M., Rankin Macgill, A., Smith, A. (2007). Teens and Social Media, Pew/Internet, http://pewinternet.org.

Maisonneuve, N., Stevens, M., Niessen, M. E., and Steels, L. (2009). Noisetube: Measuring and mapping noise pollution with mobile phones. In ITEE 2009: Proceedings of the 4th International Symposium on Information Technologies in Environmental Engineering.

Maloney, J, Silver, J. Brennan, K., Monroy-Hernandez, A., and Resnick, M. (2011) Mobile Scratch, Retrieved online at http://llk.media.mit.edu/projects.php?id=1974, on July 16, 2011.

Mistry, P. Maes, P. and Chang, L. (2009). WUW - Wear Ur World - A Wearable Gestural Interface. In CHI'09 extended abstracts on Human factors in computing systems, Boston, USA.

Myers, B. A., and Ko, A. J. (2009). The Past, Present and Future of Programming in HCI. In Human-Computer Interaction Consortium (HCIC'09), Winter Park, CO. February 4th -8th.

Nelson, T. Computer Lib: You can and must understand computers now / Dream Machines: New freedoms through computer screens—a minority report (1974), Microsoft Press, revised edition 1987.

Thomas, M. (2007). Trends and Evolution in the Wireless Communications Industry - a perspective from Ericsson. Wireless Connections Conference, November. http://www.vitel.ca/wc2007/documents/WC07_Thomas.pdf

Wang, G., Essl. G., Penttinen, H. (2008). Do Mobile Phones Dream of Electric Orchestras? In Proceedings of the International Computer Music Conference (ICMC), Belfast.

Weinberg, G. M. (1971/1985). The Psychology of Computer Programming. John Wiley & Sons, Inc., New York, NY, USA.

Weiser, M. (1991). "The Computer for the Twenty-First Century," Scientific American, pp. 94-104, September.

Wingfield, N. (2009). Time to Leave the Laptop Behind. Wall Street Journal, February 23, http://online.wsj.com/article/SB122477763884262815.html

Bridging the Silos: Curriculum Development in the Arts, Sciences and Humanities

http://wp.me/P2oVig-kp

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ABSTRACT

Higher education has long been departmental in nature (dating back to the 19th century), and becomes more restrictive as a student moves from "interesting" Freshman seminars bridging a wide range of topics, through their major courses in a departmental area and finally into graduate school, where a single department awards their degree based on a usually narrow set of course requirements and a thesis or dissertation. However, in the 21st century, investigators are finding that there are often tools, information, resources and even points of view from other disciplines that can elucidate and even answer the problem they are studying. Many studies recommend "big" solutions that require fundamental changes to hiring, promotion and tenure, funding and support, and evaluation of grant proposals and publications in cross-disciplinary areas. This study suggests a "small" solution: the creation of a compendium of arts-science-humanities cross-disciplinary curriculum that will encourage faculty to offer such courses. A Call for Contributions was initiated in July of 2102, based on an earlier Call for Courses in 2009 via the Leonardo Journal (http://www.leonardo.info/index.htm), a web site was created and submissions were posted at http://www.utdallas.edu/atec/cdash/ . The data from the courses was analyzed as to the cross-disciplines, level of offering (graduate vs. undergraduate), geographical location and the department offering the course.   Suggested actions include specific ideas to enhance networking and visibility, address lack of information about geographical bases for cross-disciplinary courses, and encourage federal funding agencies to approve a research effort to demonstrate the effectiveness of cross-disciplinary art-science-humanities courses in training the scientists, artists and scholars of the next generation.

INTRODUCTION

In 2001, Stephen Wilson wrote "The arts and sciences are two great engines of culture: sources of creativity, places of aspiration and markers of aggregate identity." (Wilson 2001) Art has a serious impact on student creativity and innovation. Students who engage in art-making are more inclined to take risks, create collectively and individually, work in groups, think "outside the box", transfer skills between disciplines, learns to speak persuasively, network, are willing to

fail and can disregard the dominant point of view to create new perspectives. (Reid 2011) Indeed, the National Academies have remarked that the need for interdisciplinary education is driven by increasingly complex problems that cut across traditional disciplines and recommended "…students should seek out interdisciplinary experiences, such as courses at the interfaces of traditional disciplines…" (National Academies 2004).

BEYOND PRODUCTIVITY

In 2003, Beyond Productivity: Information, Technology, and Creativity, a committee composed of educators from several major universities, corporate researchers and working artists identified several barriers to collaboration between the arts and information technology. The barriers to collaboration in the arts, sciences, and humanities generally are the same and include the presence of academic silos, lack of funding, the minor role mainstream arts play in many major institutions, and the difficulty of creating hybrid collaborations. The arts play a small part in the general education requirements of the state universities in the three largest states in the Unites States: California, New York and Texas. The California State University System general education requirements include only one course in the arts and one in the humanities, as opposed to four courses in math and sciences; New York and Texas requirements are essentially the same, with some institutions, such as the University of Texas at Dallas requiring far more math and science – 5 courses – and the same level of arts and humanities. The recommendations in Beyond Productivity to colleges and universities, primarily to administrators, included the support of interdisciplinary curriculum at the undergraduate level. Other recommendations were "big" solutions that require fundamental changes to hiring, promotion and tenure, funding and support, and evaluation of grant proposals and publications in cross-disciplinary areas. (Mitchell 2003)

THE NEED FOR CROSS-DISCIPLINARY CURRICULUM

In the 21st century, investigators are finding that there are often tools, information, resources and even points of view from other disciplines that can elucidate and even answer the problem they are studying. However, higher education has long been departmental in nature (dating back to the 19th century), and becomes more restrictive as a student moves from "interesting" Freshman seminars bridging a wide range of topics, through their major courses in a discipline and finally into graduate school, where a single department awards their Masters or Ph.D. degree based on a usually narrow set of course requirements and a thesis or dissertation. Graduate students who wish to take courses in other departments are often told that those courses "don't count" towards their degree, sending a negative message. Faculty are told that they may not "get full course credit" for their course if they team-teach with a faculty member in another department. Issues of funding, resources and evaluation are difficult for faculty who cross disciplines. New programs and centers are trying to bridge this gap, but most institutions do not offer "cross-disciplinary" courses in their standard curriculum. Much work needs to be done, not only to encourage institutions and administrators to offer such courses, but to assist instructors with examples of courses that cross from science, technology, engineering and mathematics to the arts and humanities ("STEM" to "STEAM") and that will inspire them to create courses, either by themselves or in collaboration with other faculty.

INTERDISCIPLINARY AND INTEGRATIVE STUDIES

Even though interdisciplinarity and interdisciplinary studies are terms that are more closely associated with the 20th century, the concept has historical antecedents in Greek philosophy. Aristotle's division of the various disciplines into the area of knowledge (theology, mathematics and physics), the practical subjects (ethics and politics) and the productive subjects (fine arts, poetics and engineering) were then tied together by philosophy as the universal field of inquiry. Up until the end of the nineteenth century, the word "science" was often used interchangeably with "philosophy", to mean all forms of knowledge rather than particular branches of it. From the 1830s onward, the term "science" began to refer to the natural sciences. (Moran 2010). Nietszche attacked the rise of disciplines in his essay We Scholars, which he saw as a creation of the research-oriented German universities. The specialized "scholar" replaced the "philosopher" as a way to climb the career ladder within a professionalized society. The university was becoming a closed institution, through the creation of departments, learned societies and journals, and the acquisition of a Ph.D. in a specialized subject. The term "interdisciplinary" emerged within the context of concerns about general education in the mid-1920s and became common usage in the social sciences and humanities after World War II. (Moran 2010)

There are still many barriers to interdisciplinary work, including different types of training, institutional context, and different pedagogical systems. Study in the humanities tends to be historically organized, while in the sciences knowledge is seen as cumulative, with study focusing on the most up-to-date discoveries and research, characterizing the history of the discipline as a mere stepping stone to the current work. C. P. Snow delineated this division in his oft-quoted The Two Cultures and the Scientific Revolution, a lecture delivered Cambridge in 1959, about the "gulf of mutual incomprehension" that existed between the sciences and the humanities. Those who cite this gulf often forget that Snow suggested that the best way to improve the situation was education and particularly interdisciplinary studies. (Snow [1959] 1998)

The current climate of emphasizing assessment in all areas of higher education has been extended to interdisciplinary courses, which have their own unique challenges in defining objectives and setting goals, given that they must often meld these from different areas. Many universities now have suggestions for faculty who engage in interdisciplinary teaching, including defining objectives, specifying outcomes, identifying issues, encouraging critical thinking, and generating evaluative rubrics. (San Francisco State 2010). While they do not directly address the intersection of the arts and sciences, there are long-standing organizations that do. The Association for Integrative Studies, formed in 1979 to " promote the interchange of ideas among scholars and administrators in all of the arts and sciences" maintains a website at http://www.units.muohio.edu/aisorg/ that includes a variety of resources, including links to assessment references, a survey of graduate programs, peer-reviewed syllabi, and job listings for interdisciplinary programs. Instructors of art-science-humanities curriculum would be well served by studying the rich tradition of interdisciplinary and integrative studies, in order to ameliorate some of the barriers that still exist in university departments and disciplines.

METHODOLOGY

In November of 2009, Drs. Victoria Vesna and Roger Malina sent out a call for curriculum through Leonardo, a publication of the International Society for the Arts, Sciences and Technology (http://www.leonardo.info/).   A second call for curriculum was issued in July of 2012, posted to Leonardo and over 10 LinkedIn Sites in art, science and technology.

INTERNATIONAL CALL FOR EXAMPLES OF ART-SCIENCE-HUMANITIES CURRICULA

Leonardo Executive Editor Roger Malina and UT Dallas doctoral student Kathryn Evans are interested in examples of courses and curricula that are in the art-science-humanities field such as courses on art and biology, music and mathematics, art and chemistry, dance and environmental sciences, etc. The call is an re-launch of a similar call issued in 2009 (http://www.leonardo.info/isast/announcements/LEF_ArtScience_curricula.html) and will be included in a Advocacy White Paper (Breaking Down the Silos: Curriculum Development as a Tool for Crossing Disciplines in the Arts, Sciences and Humanities) that is being developed in response to the international call for Advocacy White Papers issued by the network for Science Engineering Art and Design (http://sead.viz.tamu.edu/index.html) The White Paper is being developed with an international advisory group consisting of Paul Thomas (Australia), Edward Shanken (Netherlands), and Christo Doherty (South Africa).

We are interested in the broad range of all forms of the performing arts, including music, dance, theatre and film, and the visual arts; and connecting to all the hard and social sciences. We are including art and new technologies (eg: nano tech) but in general not new media curricula unless they include an art-science component.

Individuals who have taught an art-science-humanities course at the university or secondary-school level, in formal or informal settings, are invited to contact Kathryn Evans, with details of their curriculum, at kcevans@utdallas.edu. Please include permission to include your course on the Curriculum Development in the Arts, Sciences and Humanities (CDASH) website http://www.utdallas.edu/atec/cdash/

A website at http://www.utdallas.edu/atec/cdash was created to post these courses and faculty where contacted for permission to list their courses, with their institution and brief descriptions, on the site. They were also asked to send any other courses they wish to have included and to update their descriptions. Permissions and updates were received for over 70 courses, along with additional material. The site also contains a mission statement, relevant literature, programs and research centers and other areas of interest. Contact information for additions or corrections is included, and interest in a specific course will be forwarded to the relevant instructor. The website was expanded to include these new contributions, including an area for Primary and Secondary Curricula, other Calls for Contributions, and other areas of interest.

RESULTS

All courses were cross-disciplinary in nature, either general science and the arts, or a specific science and the arts, or a specific science and a specific art. Courses included both undergraduate and graduate level curriculum and some K-12 curricula in the United States, as well as courses in medical schools. It is clear that the K-12 offerings are of vital importance to higher education efforts in this area. However, the issues in K-12 education and higher education, while connected, are distinct from one another in the way curriculum decisions are made and implemented. Hence, we have chosen not to discuss the K-12 curricula at this time, as they are outside the scope of this research. Submissions were received from Australia (5), Canada (8), Germany (7), Italy (1), Netherlands (4), Russia (1), Serbia (1), United Kingdom (8), United States (42). While the focus of this effort was in art-science-humanities curricula, a few submissions involved computer science, cognitive science, sociology and psychology. The areas are indicated in the chart in Appendix A. Specific submissions are listed in Appendix B. The largest areas were biology (19.74%) and visual arts (68.42%).

Very few couress in theatre, dance or music were submitted. Some of the submissions did not meet the precise criteria as some combined the "hard" and "soft" sciences but not specifically the arts. Overall, there were approximately the same numbers of undergraduate courses (46%) versus graduate courses (54%). However, the breakdown between US courses (undergraduate 67% vs. graduate 34%) and non-US courses (undergraduate 22% vs. graduate 78%) was significant, with a higher percentage of graduate offerings in the non-US population. In the US, 15 courses (36%) were offered in science departments, 14 (33%) were offered in arts departments and the remainder (13 courses or 31%) were offered by interdisciplinary programs, an almost equal distribution between the three offering departments. Outside the US, 12 courses (33%) were offered in science departments, 18 were offered in arts departments (50%) and the remainder (6 courses or 17%) were offered in interdisciplinary programs, clearly a much heavier weighting towards art programs. This distribution suggests that different areas of the world conceive of interdisciplinary curricula in a different context and is an area ripe for further research.

The compilation is also admittedly heavily weighted to courses in the United States (53%), due to the initial posting in an American journal. This sample is by no means representative, but a response to a specific call. It does however exhibit the large variety of cross-disciplinary courses that are being offered across all the various fields of science and the arts. In most cases, the courses are being offered by a single individual in a discipline who has an interest in another discipline. Very few team-taught courses were observed. Two notable exceptions to these observations were the programs at UC Davis, which connects faculty from multiple disciplines in the Art Science Fusion program; and the San Francisco Art Institute, which offers courses through their Interdisciplinary Studies program in the arts and biology, mathematics and astronomy. "Science, Technology and Society", a new program at Stanford, provides faculty with a space "to think about interdisciplinary issues that may not necessarily have a home in their own department." (AACU 2012). While the focus of this study was art-science-humanities, this initial compilation of courses further indicates that there is a increasingly "fuzzy" border between the arts, sciences (both hard and soft) and the humanities.

This study also did not address the growing body of "informal" education courses now being offered over the Internet. There is a growing hacker/maker/"Do it Yourself"/ citizen scientist population who now explore the intersections of the arts, sciences and humanities through courses offered on MMOCs (Massive Open Online Courses), informal workshops and other community based art-science-humanities educational activities. Additionally, institutions of higher education are developing coursework with non-profit organizations to enhance their own online learning abilities. MIT, Harvard, the University of California at Berkeley and the University of Texas System have recently partnered with EdX, a non-profit venture designed specifically for interactive study via the web. This rapidly expanding educational development is also an area ripe for investigation.

SUGGESTED ACTIONS

Suggested Action #1: Networking and Visibility

To date, no comprehensive inventory or study of cross-disciplinary course curriculum has been conducted. The current website invites contributions in order to expand the listings. A call for courses can be initiated through the College Art Association (http://www.collegeart.org/) and other networking organizations in the arts and sciences such as the Art & Science Collaborations, Inc.(http://www.asci.org/). In order to attract submissions from Europe, international organizations like YASMIN (http://www2.media.uoa.gr/yasmin/) could be contacted. A new call for courses should be initiated through SEAD (Network for Sciences, Engineering, Arts and Design, http://sead.viz.tamu.edu/). A proper and extensive survey of such curriculum would encourage faculty members in art and science disciplines to offer such courses and collaborate with other faculty in complementary areas.

Barrier: Cross-disciplinary art-science-humanities instructors are isolated and often work with no knowledge of best practices, other instructors and courses, and possible collaborations.

Target: Instructors of cross-disciplinary curricula

Solution: Networking and Visibility
Suggested actions: A dedicated website, designed to assist instructors with information about other curricula, including a cloud-based syllabi resource, a blog for communication, links to best practices in interdisciplinary curriculum; and announcements of international conferences in art-science-humanities efforts and conferences. The CDASH website could be expanded to include these areas. This could lead to heightened presence of the website in academic journals and websites.

Suggested Action #2: Geographical Study of Cross-Disciplinary Art-Science-Humanities Curricula

While many "art-science" papers and studies call for "big" solutions, the "small" solution of art-science-humanities cross-disciplinary coursework at the undergraduate and graduate level could be an important part of a student's education, creating a generation of artists and scientists that will see these collaborations as natural and necessary. Students already live in a highly

technological world where they move seamlessly across science, technology and the arts and humanities. However, we have not yet used current available technology to study where these courses are being offered and in what context. A study of "informal" art-science-humanities education, with an emphasis on community engagement would add to the overall knowledge of current offerings.

Barrier: Lack of information about where art-science-humanities cross-disciplinary curriculum are currently being offered and their impact on the educational environment

Target: Instructors, administrators and funding agencies for higher education

Solution: Asset mapping efforts of art-science-humanities cross-disciplinary courses and workshops, both formal and informal

Suggestion actions: An international study that uses asset mapping tools as a way of defining the current "state-of-the-state" and identify geographical nodes and centers of learning. This could include both formal, for-credit courses, on-line educational sites and local informal courses.

Suggested Action #3: Integration Through Research

Cross-disciplinary art-science-humanities courses are still rare in most university degree plans and are still not a part of standard curriculum at the tertiary level in both the undergraduate and graduate programs. Administrators and curriculum designers are focused more on limiting the number of electives to increase graduation rates with minimal time to graduation and hence a reduction in cost to the student. The requirements for tenure and promotion, course credit, and funding are distinctly disciplinary in most universities. Cross-disciplinary teaching and research is not rewarded in the current evaluative process. The most effective way to do so would be to foster an environment where cross-disciplinary courses are offered and resources are made available to instructors who wish to teach them. Further, we must foster research that helps justify the inclusion of such courses into standard university degree plans. This requires substantial evidence that cross-disciplinary curriculum is a valuable part of every student's education.

Barrier: Cross-disciplinary art-science-humanities curriculum is not seen as valuable in degree plans

Target: Administrators and curriculum designers in higher education

Solution: Research and Integration

Suggested action: A nationally funded research effort to investigate the usefulness of cross-disciplinary art-science-humanities education with an eye towards answering the following questions: Are students who have taken cross-disciplinary art-science-humanities courses more accepting or interested or explorative of areas outside their majors? Are they more innovative? Can they think "outside the box"? Can they become members of the "Creative Class"? More specifically, students who are currently taking cross-disciplinary courses should be evaluated

before and after their curricular experience to study the effects of this kind of education. These students are the future generation of scientists, artists and scholars. Until we can demonstrate the clear usefulness of this kind of curricula, it will be difficult to convince administrators and curriculum designers that this kind of curriculum has a clear value and should be included in existing degree plans.

References

AACU (Association of American Colleges and Universities). "Liberal Education for the Twenty-First Century: Science, Technology and Society at Stanford University." AACU News., 12 April 2012. Web. 19 Apr 2012. <http://www.aacu.org/aacu_news/AACUNews12/april12/feature.cfm>.

Mitchell, William J., Alan S. Inouye, and Marjory S. Blumenthal. Beyond Productivity: Information, Technology, Innovation, and Creativity. Washington, D. C. : National Academies Press, 2003. Print.

Moran, Joe. Interdisciplinarity: The New Critical Idiom. 2nd. ed. London and New York: Routledge, 2010. eBook.

National Academies. Committee on Science, Engineering and Public Policy. Facilitating Interdisciplinary Research (Washington, DC: National Academy Press, 2004), 4.

Nietzsche, Friderich. "Published Works | Beyond Good and Evil | We Scholars." The Nietzsche Channel. N.p.. Web. 21 Oct 2012. <http://www.thenietzschechannel.com/works-

Reid, Theresa. Art-Making and the Arts in Research Universities. 4-6 March 2011. Ann Arbor, MI: 2012. Print. <http://arts-u.org/wp-content/uploads/2012/03/ArtsEngine-National-Strategic-Task-Forces-Interim-Report-March-2012.pdf>.

Snow, C. P. The Two Cultures. New York, NY: Cambridge University Press, [1959] 1993. 4. Print.

Wilson, Stephen. Information Arts: Intersections of Art, Science, and Technology. Cambridge, MA: Leonardo Books, 2001. Print.

"Top Ten Suggestions for Teaching and Faculty Development." Top Ten Suggestions for Interdisciplinary Teaching. San Francisco State University, 10 2010. Web. 23 Oct 2012.

SEAD: From Success to Succession

Coordinator: Bronac Ferran

In this paper I try to draw together fragmented and often disassociated viewpoints along the fractured lines and boundaries which together form the disparate field of SEAD. I draw on views of respondents from across a spectrum of SEAD related interests who have responded through interview, conversations and written responses to a questionnaire (included as Appendix 1 below) which explored points made within the abstract, also below.

The initial abstract written by me to stimulate responses at the outset of the SEAD call references views of important commentators within the art-science-technology axis in the late 1960s. Consideration of earlier writing and developments in the art-science-technology-engineering fields is an important step to take. As the abstract below states now there is often a sense of little cumulative knowledge or wisdom in the sector. This is reflected in the fact that basic arguments for the importance of combining different disciplines continue to need be made in various scenarios. As has been recently illustrated by the press/media coverage of comments by James Dyson, Provost of the Royal College of Art *give ref*, there is a tendency for press and media coverage to feed and feed on polarised positions, over-simplifying and ignoring more subtle or complex perspectives. This has been a frequent occurrence since Sir Charles P. Snow wrote his two papers for the journal Encounter in 1959 on 'The Two Cultures and the Scientific Revolution' which on examination of source material reflects a far more nuanced position than that often since extrapolated and which has served to underpin journalistic rhetoric on several occasions since about the mutual antipathy of arts and science practices. But Snow was far from pushing a straightforward arts-v-science line; indeed in his second article he critiqued above all the separation of pure science and scientists from engineering and applied and industrial engagement; 'Pure scientists and engineers often totally misunderstand each other…Pure scientists have by and large been dim-witted about engineers and applied science…Their instinct….was to take it for granted that applied science was an occupation for second-rate minds'. He describes how the second world war had served to shift these perceptions in favour of understanding the value of production and credits the USA and Russia with a much less intense 'national passion for specialisation' than that of the UK but his overall message in the text is not that the sciences and the humanities don't engage with each other but that factors such as politics play a significant role and in his view Western educational policy needs to speedily connect the abstract and the purist with the practical and the applied in order to avoid a growing Communist dominance throughout the world (with the Russian educational system seen by him as much more advantageous from an interdisciplinary perspective).
The value of establishing and recognising a lineage of critical reference (through identification of foundational texts that need to be read directly) to inform current discussions , debates and emerging pedagogical discourse is a key part of the main action identified below.

In establishing this lineage we cannot ignore the vital role played by environmental, social and political factors as part of the context for seminal works. We must also in this context include a dimension rarely mentioned in arts-science discourses today but one which is strongly connected

to the lineage of abstraction – i.e. the dimension of the spiritual or what we might more often today choose to call the ideological or ethical. The abstract included a very brief reference to Naum Gabo whose views on success expressed in 1969 in Studio International are well worth our reflection now:

'There is no indication of success up to now in the bringing together of art and science. To achieve success the artist must be spiritually at home in the field of science so he can think and feel in the same way as the scientist. A spiritual union, not a technical one, is requested'.

The abstract also cites Jonathan Benthall whose perceptive monthly columns in Studio International charted a series of developments from March 1969 into the early 1970s – in retrospect a formative and deeply significant period. Benthall articulated something which often tends to removed or ignored with respect to inter and transdisciplinary practices – eg the divergent nature of the processes involved. He wrote of how 'art and science have common roots in the spirit of man but they are quite distinct activities' and of 'how there is no apparent correlation between the status of a given artist and the validity of his scientific assumptions…the discontinuities between science and modern art are as interesting as their interaction'.

Also writing in 1969 in Studio International, pioneering and visionary artist Gustav Metzger elucidated a complex position which argued for engagement with technology but from a position of collusion with specific scientists who in his view were advanced in their understanding and critique: 'whilst more and more scientists are investigating the threats that science and technology pose for society, artists are being led into a "technological kindergarden", the idea being that the artist can amuse himself and some of the populace with the gadgetry of modern life'…'the conflict of artist and machine is entering a very critical phase…very often a defeated subject comes as close as possible to that force that has defeated him….can society afford to let artists have access to technologies – can it afford not to?...society is desperately in need of information about itself, needs to retain links with the past, demands the disappearance of the barriers between science and arts'.

This White Paper therefore takes forward the agenda outlined in the initial abstract and seeks to argue for recognition of the complexity and divergence of views and processes within the SEAD spectrum as both a strength and an important factor in constructing a policy framework for the future. The involvement of 'generous visionaries'who are not all university based or representing insitutions in formulating the actions suggested below has been an important element in shaping the paper's direction.

Abstract

Amnesia can dominate when it comes to building new forms of support for art/science/technology research and practice. Despite practical experiments and theoretical analysis stretching back for more than a century, there is often a 'year zero' assumption – a sense of building something entirely new. Structures and systems of support tend to come and go with few if any signs of critical accumulation. This White Paper will reference the lineage behind

highly contemporary practices and argue that accessing the critical wisdom of earlier pioneers across arts and science borders is an important part of strengthening the seemingly new. Often these pioneers have had migratory careers, moving between institutions or even countries, which has contributed to a sense of dispersal of knowledge and a lack of integration into formal structures. We should explore some of the challenges involved with drawing together distributed viewpoints, disparate processes and (often) contrasting ideologies. We need to observe a continuum of 'praxis' alongside the joy in 'discontinuity' perfectly described by Jonathan Benthall when he commented, writing in Studio International in 1969, on how: ' discontinuities between science and modern art'…are….'as interesting as their interactions'. Benthall also wisely pinpointed the value of difference and divergence within SEAD practices. In his view: 'there is no apparent correlation between the stature of a given artist and the validity of his scientific assumptions'. In 1969, also in Studio International, the great artist-engineer Naum Gabo wrote about how he had seen little success in terms of bringing together the arts and sciences. This leads to a second very important challenge and question for this White Paper which is to ask how might we choose to evaluate success across the breadth of the terrain signified by a framework such as SEAD? Without evaluative processes there can be no methodology for learning and passing on wisdom. As curricula and reading lists are being formed to underpin emerging Masters courses in 'art and science' might the SEAD initiative finally help signpost a stable direction in this productively unstable terrain? Is it feasible to produce a summative assessment of what constitutes success in the interdisciplinary domain and what might this mean for future institutions? How might art and science pioneers now define success? How might the value of preceding events and practitioners be more readily accessed? The SEAD community is invited to contribute to the development of proposals to address some of these fascinating challenges.

Responses

In terms of addressing some of the challenges above and to inform the SEAD policy agenda, articulate responses to the questionnaire included below have been received. These have been vital in shaping the suggested actions also outlined below. Two examples of the responses from leading female pioneers are enclosed as Appendix 2 and 3.

Articulated very strongly has been a desire for a series of interconnected steps to address disappearing histories and embodied narratives in the SEAD domain. The point has been made very strongly 'that any SEAD initiative should involve active practitioners and not, except for aspects of management perhaps, career academics'.
It is proposed that through the SEAD project leadership could be established internationally to draw together critical archives and case studies, both at independent/individual and institutional level, to form an inclusive and assessible map of important initiatives both in time and space.

Given the highly diverse nature of the practices involved, as well as the ageing of pioneering artists etc within the field, it is suggested that a peer group should be established to urgently inform the creation of processes and procedures to ensure there is no loss of critically significant context, individual memories and narratives, to build a framework for international co-operation in the field given the highly migratory nature of work and leading practitioners and to activate a programme of work to establish terms of preservation, long-term curation, archiving and criteria

for identification of foundational works, texts, activities to inform longer-term educational programmes etc. Whilst certain archives and collections do exist there is no linking framework or narrative that could help new researchers locate these or find the people who may wish to share their stories, despite the potential for online or networked communication. As pioneering figures age, mobility generally becomes more challenging. For a field premised on rapid exchange and encounter and on travelling the world to conferences which have acted as core centres of connections the ageing of its pioneers and the emerging of new audiences and students seeking direct connection with precedent works and people, there is a need for a new kind of creative collaboration which the SEAD project can help endorse.

There were many comments on the need for this action:

'…the lack of history…so many people reinventing wheels….this has been exacerbated by the recent 30 year domination of post-modern thinking and the anti-historical stance of its more extreme ideologues…..'

'The Histories as written are full of gaps, missing works, missing archives and nothing is fully connected'….

'A full historical study is needed that looks closely at the informal connections and influences with as much attention as is paid to the formal ones'.

'Sympathetic social historians' should be involved to help build the missing narrative.

'If it were up to me, I'd organise a seminar/workshop/salon and invite the attendees I think most exciting, eccentric and knowledgeable in the field. The ambience of such events is very important to open people's imagination and memory. And I would ask them some of the questions you are exploring here…. then publish the results'

 'Maybe we edit a book – curate sections, multiple authors, but the organisation of the book is key to talking about the parts of the story that are currently less well contextualised or have been forgotten'.

'there is a pressing need for such an international network in this area with agreed standards for archiving, preservation and shared criteria of evaluation. A standard of tagging, access and preservation has to be agreed and implemented'

'I would suggest that key players in the field such as Roger Malina, Ernest Edmonds, Roy Ascott (& others) could identify a group of key people to develop a programme that not only produces documentation of key events, people and influences but also promotes the dissemination of best practice. It would be important to include people from history (social and cultural) and ethnography as well as artists, scientists etc.'

The obstacle to this action was eloquently described by one respondent as follows:

'The atomisation of archives, the lack of a general network and the loss of platforms for works that are technically obsolete. Basically a spectacular failure of institutions to maintain seminal works in the field.   The variation in state funding has meant that this is still a patchy and piecemeal effort. To date no educational institution has taken a proper lead apart from Donau-Universtat Krems'.

Other obstacles include:

the difficulty of integrating the variegated practices of individuals who may work outside situations of scholarship in academic sense and yet who have important source material, are living case studies and have much knowledge and skill to share.

The proposed Action is summarised as follows:

'Cultural institutions, pioneering individuals and universities must form an alliance to look at the most effective tools for archiving, documentation, study and fostering of new cross disciplinary approaches beyond the silos. The biggest deficit is consistent funding…an open source, micro funded initiative by all interested parties may now be the way forward. The pioneering work of individuals, businesses/companies and foundations which may not fit easily into the academic domain should be acknowledged and included within this process and where possible making available source material within an integrated archival framework should be prioritised so that vital contextual factors are also taken into account'.

The stakeholders who would be involved in the development and implementation of this action include:

Artists, scientists, technologists, museums, archives, libraries, publishers, policy makers, academics in interdisciplinary fields, social theorists and cultural historians, history of science and technology institutions, art schools, students, doctoral researchers, further and higher educational establishments; higher education and research funding interests in US and rest of world who should agree a series of parallel priorities to make sure the mapping/oral history/visualising the leading activities exercise is inter/transnational as befits the nature of this disparate and dispersed practice.
The SEAD project could provide a lead internationally working closely with the Leonardo network which already connects many of the key stakeholders and has a reputation for non-biassed, non-hierarchical approaches to the issues under consideration.
In the course of identifying this key priority for action, a number of other fascinating comments and observations were made which are worth sharing here:
'Make a prominent network of where to find stuff to make things out of and where to live and work cheaply to make things. Like a Craig's List for SEAD practitioners'.
'In spite of the "success" of the purely scientific experiment, the hybrid "succession" of art/science creativity evokes little outside recognition or inside exchange. The SEAD initiative can finally help signpost a stable direction in this productively unstable terrain. It is feasible to produce a summative assessment of what constitutes success in the interdisciplinary domain and what might this mean for future institutions".

"As a result of rapid changes in technology, many major works made even 10 years ago can no longer be shown or are disappearing without a trace. If this situation is not addressed, we face losing an artform that is a central part of our post-industrial digital culture. To date, systematic global preservation and documentation campaigns do not exist. Many important online documentation and research projects are also disappearing from the web. As they falter, we risk losing their valuable material forever. Contemporary scientific research relies on access to shared data. The same is true of the Arts and Humanities, which lack a concerted international policy for sustainability and support of the digital heritage, such as exists partly in the natural sciences' – excerpt from http://www.mediaarthistory.org – quoted by one respondent.

'I am increasingly uncomfortable that practising artists who do not have advanced academic degrees are not having access to high-level (university) collaboration….there is also a danger that things are becoming narrowed and codified, thereby discouraging the kind of research and experimentation that produces "happy surprises"…I would emphasize the value of working with others "whose processes are disparate and who have vastly different ideologies"'.

Invited to comment on whether evaluative and assessment criteria exist or should exist within the field of SEAD responses responses diverged greatly. Some felt that such a question was impossible to answer and others wished to avoid having to codify the disparate and individualistic actions. This represents well an overall wariness about stabilising the fundamentally unstable whilst desiring further continuity and legacy to ensure important things are not forgotten.

One respondent said: 'generalizable guidelines could be one of the outcomes from the NSEAD/XSEAD/SEAD activities' and that current criteria tended to be 'a smattering of borrowed methods from the art world or the science world. A SEAD activity generally has to satisfy both criteria to be considered successful but it usually only partially satisfies them.'

Similarly this respondent thought that 'a shortcoming of good texts and shortfall in understanding of good pedagogical practice was a considerable hindrance' and that 'the new map' could be effective in addressing this constraint and that ' the XSEAD website was an important activity and a SEAD k-12 initiative would be welcome' in possible creation (through assemblage) of a new 'canon.'

Another respondent stated:

'the criteria need to be better formed for generalizable use. They must be formed bottom-up, by researchers, for example but then taken up and endorsed by professional bodies'…..'see UTS's CCS PhD programme and the approach it exemplies. …note the importance of the multiple-inut/multiple-output view of collaborative work and, hence, the inappropriateness of a single narrow evaluation approach.'

In terms of evaluating success and its relationship to succession, one respondent addressed this clearly: 'My experience is that it takes many years for new ideas to take hold but I believe success can be measured by how far an approach becomes so entrenched in practice. When I began in the early 1990s, inter-disciplinary collaborative approaches were unusual and the use of

new technology in the arts was only just developing a larger constituency as a result of the arrival of desktop computing. Nowadays collaborative work in the digital arts is considered the norm and the technology is all-pervasive……However, the quality factor remains unresolved largely because evaluating the processes and outcomes has been left largely to chance…..'. She went on to say: 'There is no simple way of defining success in relation to the size and scope. Often the really important projects do not appear to be significant at the time but are later recognised for their seminal value (e.g. Cybernetic Serendipity).

Finally, on success, another respondent said:

'I would say that success in the field of SEAD would be when science, engineering, art and design start to work together in the creation of a new world where every little corner, every little moment and every little act in our everyday life is poetically transformed. Only when we have reached that point we could call the SEAD field a success.'

Obstacles

The atomisation of archives, the lack of a general network and the loss of platforms for works that are technically obsolete. Basically a spectacular failure of institutions to maintain seminal works in the field. The variation in state funding has meant that this is still a patchy and piecemeal effort.

The difficulty of integrating the variegated practices of individuals who may work outside situations of scholarship in academic sense and yet who have important source material, are living case studies and have much knowledge and skill to share.Lack of leadership in a distributed interdisciplinary domain. The ageing of the pioneering activities and artists/scientists in this field globally.

Action

'Cultural institutions, pioneering individuals and universities must form an alliance to look at the most effective tools for archiving, documentation, study and fostering of new cross disciplinary approaches beyond the silos. The biggest deficit is consistent funding…an open source, micro funded initiative by all interested parties may now be the way forward. The pioneering work of individuals, businesses/companies and foundations which may not fit easily into the academic domain should be acknowledged and included within this process and where possible making available source material within an integrated archival framework should be prioritised so that vital contextual factors are also taken into account.'

The stakeholders who would be involved in the development and implementation of this action are:

Artists, scientists, technologists, museums, archives, libraries, publishers, policy makers, academics in interdisciplinary fields, social theorists and cultural historians, history of science and technology institutions, art schools, students, doctoral researchers, further and higher

educational establishments; higher education and research funding interests in US and rest of world (who would be encouraged to set parallel priorities for research funding given the dispersal of leading practitioners and centres of activities throughout the world).

See Appendix 1 – for Questionnaire

See Appendix 2 Case study/response to Questionnaire by pioneering artist, Janet Saad-Cook, to whom sincere thanks are extended by me.

I would also like to thank the following whose words have informed this White Paper: Jonathan Benthall, Paul Brown, Sheldon Brown , Linda Candy, Meroe Candy, Ernest Edmonds, Paul Glinkowski, Kathelin Gray, Gustav Metzger, Martin Reiser, Sonya Rapoport, Janet Saad-Cook, Alejandro Tamayo.

APPENDIX 1

QUESTIONNAIRE

Questions to be addressed within submissions:

Please identify your own position within the SEAD axis: are you a practitioner, a theorist, an academic, or a combination of these?

What would you describe as your 'home' discipline?

How many years have you been working with field now known as SEAD?

How do you define success within your own practice?

How would you define success within the field of SEAD?

If asked to nominate three successful projects or initiatives which you have encountered in your experience within SEAD what would they be? Feel free to mention more than three.

Please say in which case why these seem to you to have been more successful than other projects?

Do you feel confident in generalising about what success means or might mean in this field?

Do you believe there are evaluative and assessment criteria already existing in the areas of SEAD?

Who would you look to for guidance in this area?

If you do not feel these criteria exist in any generalizable way: do you feel they should and if so who should be responsible for formation of these guidelines?

Could you identify leading places within the SEAD map?

Could you identify leading texts – indispensable reading for any student of SEAD history or lineage?

What do you think are the main problems facing anyone trying to study SEAD developments within research and educational institutions?

Do you know of any interesting or important developments within education in your country or elsewhere which might be regarded as contributing to building an academic infrastructure for SEAD related activities?
Can you think of ways in which some of the gaps in terms of infrastructure may be filled or addressed?

What (new) layers of infrastructure could or should be introduced to build stronger or more successful SEAD initiatives?

Can you name or describe some case studies of pioneering figures who best represent for you good practice in relation to SEAD?

Why are these significant?

Is there a missing narrative? How might this best be written and shared?

Whose responsibility might be it to be to build stronger layers of infrastructure in terms of succession – ie memory and lineage?

Please feel free to add any other comments, self-related or related to others

APPENDIX 2

RESPONSE TO QUESTIONNAIRE FROM JANET SAAD-COOK (copyright Janet Saad-Cook 2012)

November 5, 2012

Notes for Bronac Ferran SEAD White Paper

As an artist and a theorist, I have been working in what is now known as the SEAD field for more than thirty years, beginning in 1980. My discipline as an artist is sculpture, but I use the term only as a convenience within the context of this paper because I create "situations" in which my art is experienced through the interaction of the sun with the earth.

Thirty two years ago I invented a new way to create art by fusing sunlight, time, reflection and motion, and I call this Sun Drawing. To experience Sun Drawings is to see brilliant, shimmering images of light soar across walls, evolving and dissolving as the sun makes its daily sweep of the earth. The changing images evoke a calming sense of connection to the natural world and to the silent rhythms of the earth and sky, marking the hours, the days, and the seasons.

As a theorist, I am interested in connections I find between the shape of light and the shape of the movement of time when measured with sunlight. I began examining these connections in the 1980's, along with my research at prehistoric sun marking sites in the American Southwest, particularly in studying certain petroglyphs that mark sites as sacred sun marking places. This is an area I would like to work on in collaboration with a scientist and/or a Cosmologist. I gave a seminar on this topic to the astronomers at MIT's Haystack Observatory in 2008.

Success for me: What I feel makes my art successful is that people experience my art on a deep level without needing to understand the complexities of astronomy, optics and physics behind it. They are moved by the simplicity of what is happening, the sun and earth working together creating light coherencies that are moving in harmony with time. Some ask themselves why they never thought to do this because it seems so simple; my hope is that they will then ask themselves what else exists in their lives that has such beauty and resonance but is so simple they are not seeing it… my hope is that they are then moved to see their lives in new ways. (Please see Anecdote 1)

Within the field of SEAD, I define success as having the respect and support of people I respect. It does not always mean being able to realize ones creative vision. (Please see Anecdote 2)

Regarding successful projects within SEAD, my Sun Drawing at Boston University's Photonics Center is the most successful of ones I have completed. On a technical level, we broke new ground in the following way: we designed an optical system that not only brings sunlight sixty-five feet down into the atrium and onto the Sun Drawing instrument, but also configured the system so that the sunlight moves in harmony with the earth's rotation. (Traditional heliostats keep the sunlight static.) The astronomer who collaborated with me is on the faculty at Boston University, and he designs optical instruments. The special aspect of this project is that we were able to program the sunlight to "move," which then enabled me to "choreograph" the sunlight, i.e. have the sunlight move across the reflective elements in specific ways. It is also the most successful because this is the Sun Drawing I refer to in Anecdote 1, and because it has been used for educational and research purposes by Boston University since it was completed in 1997.

Two additional projects were designed but not built that I feel are in this category of a successful SEAD project. One was a concept design I was asked to submit for the Nice Observatory, France (1996). The other was a concept design I was asked to submit for a national memorial in Beirut, Lebanon (2006). The Beirut design is based on a transparent sundial concept I have been experimenting with since 1989.

The Nice Observatory project involved a subterranean chamber with crystalline light sources rising from the earth to admit sunlight below to activate Sun Drawing instruments. In addition to astronomers at the observatory, my team included an architectural firm in Paris and an architectural engineering firm in London. The most unique part of this project is that it was to be sited in alignment with one of the Nice Observatory's historic astronomical instruments called Le Petite Meridien, and I incorporated an event of light that would pass from the subterranean chamber to the Meridien instrument at midday, as the sun crossed the local meridian. This project received funding but was never allowed to be built.

For the national memorial in Beirut, my architect/collaborator and I designed a complex of transparent walls memorializing all who died in the 15 year war. It was to be a 30 feet high by 50 feet wide transparent sundial composed of optically coated glass walls inscribed with the names of the dead. When touched by sunlight, the walls were designed to send forth brilliant shafts of light and color across the grounds of the memorial, moving and shifting with changing sunlight, carrying the names of the dead within the patterns of light, as part of marking time and the seasons. The science (astronomy) of this project would be a unique challenge for the scientists working on it, due to the transparency factor of the sundial/calendar.

Success in SEAD field: I do not feel confident in generalizing about what success means or might mean in the SEAD field. And I suspect the evaluative and assessment criteria that already exist are ones I may not agree with because I feel the SEAD field is becoming increasingly codified. The danger in this is that it can stifle the spirit of art, sacrificing it to science, technology, academia, etc. My own measure of success is the human response to my art. It is tempting to become enchanted with process, technology, materials, research, etc., but the challenge is to transcend all of these to create art. When I learn about some contemporary SEAD projects the feeling I have is that science, technology and academics take over, and that is problematic. People respond to my art at deep, non-cognitive, levels as they recognize they are experiencing the harmony of natural forces. In many instances they become curious enough to want to understand the science, technology, etc., behind it. But it is not the technology that draws them into the experience; it is the experience that draws them to the technology. This would be my criteria for success. (Please see Anecdote 3)

Who would I look to for guidance in this area? Roger Malina is for sure someone I look to, and the publication Leonardo. I also very much support the work of the ArtsCatalyst group in London, under Nicola Triscott.

Regarding criteria in areas of SEAD, I very much believe they should be put forth for some of the following reasons: I am increasingly uncomfortable with scientists, technology experts, etc., presenting themselves as artists, and being accepted as such without regard to the quality of what they produce as "art." On the other hand, artists who use science, etc., or who collaborate with scientists, are not accepted as scientists, nor is the work they do considered significant to science. The Jonathan Benthall quote in your abstract references this, in a way, when he says, "there is no apparent correlation between the stature of a given artist and the validity of his scientific assumptions." In some of his writings this year, Roger Malina has also commented about this unequal "valuation."
I am also increasingly uncomfortable that practicing artists who do not have advanced academic degrees are not having access to high-level (university) collaboration. I do not know who should be responsible for formation of guidelines at the moment because this field is so unwieldy. But I do object to the over-emphasis on academia and technology because I believe we run the danger of keeping out some of the best artists. I suggest that more practicing artists be consulted to help create guidelines in this field, which at the moment it seems overloaded with science, technology and academia.

These are among the main problems I feel are facing anyone trying to study SEAD developments within research and educational institutions. There is also a danger that things are becoming narrowed and codified, thereby discouraging the kind of research and experimentation that produces "happy surprises." I suggest opening higher institutions to practicing artists who do not necessarily have advanced degrees so that scientists, etc. have the opportunity to collaborate with them. I would emphasize the value of working with others (to quote you) "whose processes are disparate and who have vastly different ideologies." (Please see Anecdote 4)

Pioneering efforts in SEAD field: I would cite The Exploratorium (US), ArtsCatalyst (UK), the Univ. of California Berkeley, Lawrence Hall of Science (US), Leonardo (publication). All are

significant because they began years ago (especially Leonardo and The Exploratorium) and continue moving SEAD forward, each in their own way, and they keep abreast of new discoveries, methodologies, technologies, etc.

Whose responsibility to build strong layers of infrastructure…i.e. memory and lineage? The easy answer would be art historians, curators, archival journals, etc., but I am not sure these are as appropriate today as they were in the last century…I do not have an answer… .

Personal summary notes

The main support for my art from the very beginning came from the worlds of science, business and technology, and not from the fine art community. In the realm of science, specifically Astronomy, I felt my work was very much appreciated and respected. They understood what I was doing, were fascinated with the process, and were always generous with information so that I could better understand my process. They loved the Sun Drawing instruments and often joked that they looked like "defective lenses" until you put them in the sunlight and saw amazing effects.

Corporations I approached were extremely generous in supplying me with materials, specifically Ford Motor Company's Architectural Glass Division, Dupont, who gave me significant quantities of costly space-age materials with which to experiment, particularly a gold industrial thin plastic film used to line space craft and space suits, and the Mearl Corp. (no longer in business), who were pioneers in developing industrial thin plastic light interference material and allowed me access to their research labs so that I could understand the science behind light interference films. A number of optical coating companies were generous in providing services for my early experiments. I eventually applied for and was granted a broad patent by the US Office of Patents and Trademarks.
Regarding the fine art world, in the 1980's I was being told by fine art museum curators that what I was doing was science, not art. Commercial art galleries found my art "difficult to market," and would ask questions such as "What is it I am selling to the collector? Is it the image reflected onto the wall or is it the Sun Drawing instrument that causes the image? Which is the art?" I am not critical of them because there was not yet a "language" for SEAD art. Today, it's very different and an example of how much things have changed can be illustrated by a quote in the New York Times on Friday (Nov. 2): "Art dealers are scrambling to make space to show all kinds of sculpture related to architecture."

 As a woman (and an artist) in this realm of SEAD, I was often subjected to the belief I could not possibly understand the science and technology I was working with, a view that would not have surprised Jonathan Benthall. Such an example would be that when I spoke about the astronomy involved with my process, the person might correct me by saying "OH, don't you mean astrology?" Hopefully such attitudes are rare today.

Sources of Inspiration

Researching new materials, experimenting with technologies, e.g seeing a shard of glass at an optical coating company and learning about beam splitters. My creative process travels along

parallel lines of information gathering and my need to understand the technical behind my experiments so that I make intuitive leaps …feeling the vision…and later fill in the steps to get there to understand the underpinnings of the process in technical or scholarly ways.

Researching the cycle of the sun, creating a sun calendar on my studio floor that began in 1982 and ended in 1996, watching the sun's return throughout each solar cycle. Beginning the sun calendar preceeded study of ancient sun marking sites, which then brings together the intuitive with the "technical", i.e. astronomy of the site.
Creating Sun Drawings on ancient sites, connecting my art with the ancients' and feeling connected through the sun's cycle, the same endless cycle they experienced, removing barriers of time, touching the sky together.

APPENDIX 3

Sonya Rapaport

I, Sonya Rapoport, have been a conceptual artist working within the SEAD axis for approximately 40 years. My artwork observes the scientific dogma that it must further a concept that is original to what preceded it in similar practice. My art/science hypothesis for each work is usually derived from a scientific experiment that I thought could stimulate further involvement with an "art narrative". The scientific source would be considered a "success" in that I, as an artist, have become aware of it. How to evaluate the "succession" i.e. the hybrid art/science production that would follow, to be a "success" is more evasive. I have asked these questions while creating my conceptual artwork.

For example: "The Transgenic Bagel," (1993-95) preempted the scientific discovery of considering personality traits to be genes. The"success" of the artwork was its recognition in the NATURE BIOTECHNOLOGY Journal (1997). As Jonathan Benthall said there is no apparent correlation between the stature of a given artist and the validity of his scientific assumptions. A few viewers appreciated the "Transgenic Bagel" but the stepping stones from originally engaging in the idea (including scrounging around for a scientist) to its fruition, lost its continuity of possibilities. No interdisciplinary domain was there to evaluate the "succession" resources. Another "success"/"succession" cycle to this narrative was coining the word "transgenic". This term was eventually used in gene splicing work created by other artists. The need for the gaps in terms of infrastructure may be filled or addressed with a more comprehensive network of information.

The New York Times (October 16, 2012) reported research about a computer program that will diagnose "How Do you Really Feel?" I created a similar art project in 1984. The artwork predicted that a computer will tell us how we really feel. Again the reality of the scientific research is the"success"; the"succession", a minimal "success" of the artwork" had no further recognition or exploration to my knowledge since 1984.

The recent Nobel Winners in Economic Science, Dr. Lloyd Shapely for his theoretical work ("success") and Dr. Alvin Roth's application ("succession") of Shapely's work in Market Design

provide the structure for my next hybrid "succession" interactive art piece, "Impossible Conversations", the weighting of pattern data.

In spite of the "success" of the purely scientific experiment, the hybrid "succession" of art/science creativity evokes little outside recognition or inside exchange.

The SEAD initiative can finally help signpost a stable direction in this productively unstable terrain. It is feasible to produce a summative assessment of what constitutes success in the interdisciplinary domain and what might this mean for future institutions.

Anecdotes

Janet Saad-Cook

Anecdote 1: In 1997 I created a Sun Drawing for the 7th floor atrium of the Boston University Photonics Center. Although it is the most technically complex one I created to date, it was here that I found out how little the science, technology, or complexity matters because what is important is the impact on the human spirit. One day, a building maintenance person saw me looking at another work of art in the Photonics Center collection located on the first floor of the building. He did not know I was the artist who created the Sun Drawing upstairs. He told me if I wanted to see something truly beautiful I should go upstairs to the 7th floor because when the sun shines, a picture of light appears on the walls. He placed his hands on his heart and said he did not know how it happens but it fills him with happiness every day that he sees it. This is without exception the moment I have felt most successful as an artist.

Anecdote 2: This measure of success became increasingly clear to me during the 1980's and 1990's when I envisioned creating a monumental scale Sun Drawing at the National Radio Astronomy Observatory's Very Large Array near Socorro, New Mexico. I secured permissions from the appropriate government and science entities to build the project, which was to become part of the Very Large Array Observatory. The project included all the disciplines of SEAD… art, architecture, science, engineering, and commercial construction. I established a non-profit organization, The Sun Foundation, to raise money to build the project. Roger Malina was one of the original board members.
Despite out best efforts over a period of twelve years, we were not able to raise enough money to build the project. Yet during these years, I received significant support from sources I hold in high regard, specifically from the fields of science and technology. I did not receive support from traditional or commercial fine arts organizations, an issue I discuss in more detail elsewhere. Supportive groups were institutions such as the Smithsonian Institution, the Exploratorium, The Catholic University of American Dept. of Physics, plus three years of one-person museum exhibits under the auspices of the American Association for the Advancement of Sciences, the Leonardo Prize, and a nomination for the MacArthur Genius Grant, to name a few from that time. I was invited regularly to give lectures to scientists at places such as MIT, the American Astronomical Society, The Santa Fe Institute, VLA, the Royal Institution of Great Britain, among others, as well as universities throughout the US. I also presented invited papers at the

International Astronomical Union (IAU), Commission on the History of Astronomy, in New Delhi, India (1985), and in Baltimore, MD (1988). These invitations were the result of research I have done at prehistoric sun marking sites in the American Southwest, and my studies of the 18th century architectural-scale astronomical instruments of Jai Singh in India. I consider all of these activities successes within the SEAD field.

Anecdote 3: In 1979 I visited the Holography Museum in the Soho area of New York City, and I saw something deeply stirring in the large holograms on exhibit. At the same time, I intuitively felt there must be a way to create phenomena of light without all the paraphernalia. Even though this experience predated my work with sunlight, I left the museum with the certainty that someday I would create forms of light without all the extraneous technology.

Anecdote 4: I personally experienced this in the academic year (1985-86) I spent as the first (and only) Artist in Residence at The Catholic University of America, Dept. of Physics. The university has an important glass research laboratory as part of the Dept. of Physics. The university learned about my art and the experiments I was conducting with glass, and invited me to do collaborative research with them. The reason this was such a rich, successful collaboration was because our processes were so different. I work intuitively as an artist, experimenting, trying anything and everything until I find what I want; the Physicists I worked with approached their work from the opposite direction, i.e. they set up the theory and then worked to prove it. We learned a great deal from each other. I was especially excited, working with the senior research scientist, because he taught me scientific methods of record keeping for each step of my process in shaping glass. These notes and journals became (and still are) extremely important to me. What they learned from me is that there are some things that are not "measurable", and therefore not replicable.

Janet Saad-Cook, November 5, 2012
www.janetsaadcook.com

Learning Computing through Game Experiences

Coordinator: P. Fishwick
http://www.cise.ufl.edu/~fishwick

Computing Culture

The field of computing is found in a wide array of disciplines including information science, computer science, and computer engineering. The culture of computing, including its formal languages, practices, and practitioners, has permeated the broader cultures of society at large. We use digital devices including smartphones and video recorders on a routine basis, and this use has changed how we think. Programming a digital video recorder (DVR) requires knowledge of tree structures, state machines, and other fundamental formal constructs found within computer science. This knowledge is learned through informal experience rather than through formal means (e.g., taking a university course). Therefore, there is a general need to teach non-computer specialists about core computing concepts because of their cultural significance. People should learn about computing, as they learn mathematics, because of its ubiquity in modern life.

Roadblocks and Opportunities

One challenge in learning computing relates to the need to entice the learner into computing through something that they find interesting and relevant. Certain games serve as a general opportunity to address this challenge since there is a pre-existing culture of game players, and one need only use this as curricular vehicle for introducing learning objectives. Games are developed using multiple disciplines, and players of the games cross disciplinary boundaries; World of Warcraft is probably played just as frequently by artists as programmers. However, there is a more significant set of roadblocks in bridging the areas of SEAD (Malina and Strohecker 2012). One of them is so basic as to be easily overlooked: writing vs. building. Some of our core approaches in the SEAD disciplines are oriented toward writing. Computer scientists write code or programs, as do humanist scholars who write the "scholarly edition." The assumption of the former group is that algorithms, and most resulting code, are written. For the latter group, writing is the fundamental rhetorical device supporting criticism. Can we challenge these assumptions? Can an algorithm be defined by an analog machine (Fishwick 2012), and can the humanist's rhetorical mandate employ audiovisual artifacts? The visual and musical arts offer opportunities in attempting this challenge: perhaps algorithms can be designed like skyscrapers, and criticism can be defined by perceptually-enabled interaction? Malina has created a phrase he calls the "crisis of representation" (Malina 2012), which characterizes the problem. SEAD Disciplines tend to be segmented using representational norms. The norms should be challenged by exploring new representations.

Game Experiences

The need to inform the general populace of computing can result in several different approaches; however, I suggest one specific approach based on interactive game technology. This approach involves exploring new representations for computing artifacts. I propose learning computing through game experiences. Consider, for example, two game experiences initiated by the same author: Minecraft and 0x10c (Notch 2012). Minecraft is a "block game" where blocks are mined, and a subculture of Minecraft has resulted where players use raw game materials to construct digital circuits (Minecraft 2012). The emerging game 0x10c is centered on the use of programming a virtual machine (DCPU-16) whose function serves as an in-game experience involving piloting and controlling a space ship. Aspects of computing, rather than being used to create games (i.e., writing game code), are instead used as virtual environments whose experiences involve learning computing. In Minecraft, one can create circuits out of virtual blocks and in the planned 0x10c, one can program a virtual computer for steering gameplay. The proposed goal is not to learn computing by authoring game code, but to leverage game-based social networks, culture, and gameplay as means for introducing computing concepts.

Aesthetic Computing Class

Many games and mods of those games can be used to create experiences that reinforce, or introduce, formal concepts found in computing. I have taught a class at the University of Florida for the past decade called Aesthetic Computing (AC 2012, ACP 2012). The purpose of the class is to broaden the representational possibilities for formal structures found in computing by using the arts and humanities as guidance. The products from this course have evolved over the years, and this past year, students used games and game engines to represent computing constructs such as data, equations, and code. One of the Spring 2012 class projects (Tadayon, Wilson, and Vo 2012) involved a simple Petri net using Minecraft features including dispensers, eggs, lava, and pistons. Figure 1 shows a side view of the Petri net. The redstone blocks in Minecraft are necessary to model message propagation needed for simulation modeling of the Petri net.
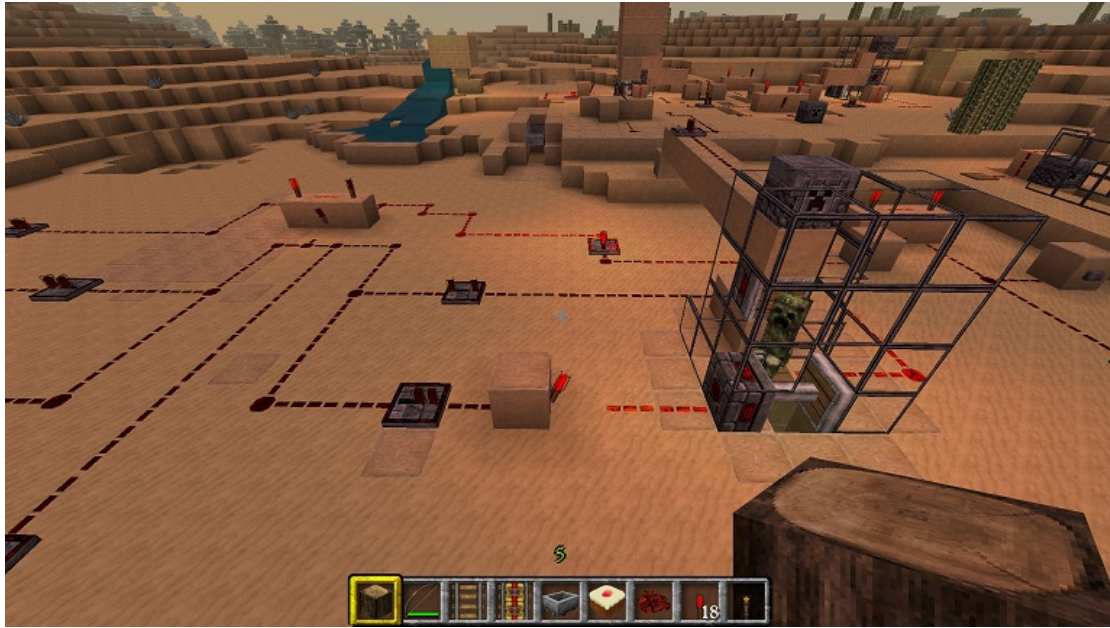
Figure 1: Side view of Petri net in Minecraft (from Tadayon, Wilson, and Vo 2012)

Using games as a means for teaching computing concepts can be seen as a form of serious gaming, although in this proposal, no new games are proposed. Instead, learning is facilitated by starting with existing game cultures such as the one around the game Minecraft. The opportunity for leveraging these cultures and adopting game-based materials as raw elements for novel representations of computing constructs separates this proposal from other work. The root idea is not new, as formal structures such as universal computers and calculators have been constructed from Legos and Tinkertoys and numerous other natural or engineered materials. The proposed curricular improvement is to build upon the past use of toy objects for constructing analog computers and to 1) broaden this concept to allow for multiple formal constructs (not only arithmetic units and universal computers), and to 2) employ game cultures, such as Minecraft, as a basis for exploring new representations of formal constructs. The assumption is that if players are drawn into subcultures of games, this sociological phenomenon can assist in learning new concepts that are contextualized within those subcultures. It is feasible to take this approach in learning any new concept, however, this proposal is based on computing concepts as a starting point.

Stakeholders and Suggested Actions

The broad, and varied, target population for concepts defined in this white paper are 1) the students who learn formal concepts of computing, 2) educational researchers who wish to explore the effectiveness of new representations on learning, 3) agencies concerned with learning (e.g., MacArthur Foundation, Bill and Melinda Gates Foundation, and the National Science Foundation), and 4) game authors and companies. Classes can be co-taught by SEAD discipline-specific teachers who wish to explore representational challenges outside of the norm: building algorithms and programs rather than writing them, and simultaneously exploring their rhetorical values within game cultures. Specific suggested actions include the following:

1. **Stakeholders**: Educational Institutions (at all levels including K-12), Agencies promoting computing education (Bill and Melinda Gates Foundation, National Science Foundation).

   Opportunity: Learning computing concepts

   Challenge: To teach computing, which has been identified as a national priority given the emphasis in STEM

   Suggested Action: Study the employment of games and game engines for teaching basic concepts in computing such as iteration, branching, recursion, and object orientation. By using games, we are leveraging popular game culture, which is common in the "millennial" population who grew up with console and mobile games. Often the learning of computing within games involves new representational forms for computing concepts. One approach has been explored by Fishwick (University of Texas at Dallas) in a field he pioneered called aesthetic computing. The aspect of this field related to computing in game experiences is called virtual analog computing (http://www.utdallas.edu/atec/docs/virtual-analog-computing.pdf). The use of games naturally leads to interdisciplinary skills required to develop game environments, including areas within the arts and humanities as well as STEM subjects—a manifold direction captured by the STEAM initiative.

2. **Stakeholders**: Educational Institutions (at all levels including K-12). Agencies promoting interdisciplinary and trandisciplinary activities (National Science Foundation).

   Opportunity: Bridging diverse disciplines

   Challenge: To provide an approach to bridge science and engineering (STEM) with the arts and humanities (i.e., STEAM emphasis)

   Suggested Action: Use games as shared virtual infrastructures in which to combine, integrate, and connect different disciplines across the academy from the arts and humanities to science and engineering. Often, disciplines involve research in topics that are distinct and separated from other areas; however, as illustrated by the multi-decade successes of the cinematic special effects and computer gaming industries, teams based on diverse talents and knowledge areas can work effectively together. Some game environments, especially those that are multi-user shared spaces, can be catalysts for this convergence, and a promotion of the STEAM concept. For example, computer scientists can work on algorithms and automation, humanists can identify and create narratives and critiques, and artists can create new sensory experiences.

3. **Stakeholders**: National Science Foundation

   Opportunity: Enhanced study of the embodied mind

   Challenge: To leverage the UT Dallas transdiciplinary ATEC center hub, and its new 160,000 sq. ft. space to better understand the relevance of the body to areas of cognition such as language in general, and formal languages (such as those in computing such as data and code), specifically.

   Suggested Action: Through the use of experiments and formal methods in social and behavioral science, strengthen current knowledge for embodied cognition (Varela et al. 1992) and "simulation" theories of cognition. To what extent do metaphors involving gestures and body sensations (movement, orientation, tactile sensation, sound) embed themselves in the artificial artifacts found in computing? What are the thought processes underlying modular coding, conditional branching, and understanding of large-scale, complex, data structures? To answer these questions will require scientifically grounded research and human subjects. Where embodiment does play a role in cognition connected with these software artifacts, new forms of representation will be required to leverage, and capitalize upon, the embodiment hypotheses. Game environments provide an excellent breeding ground for the human subject experiments as well as constructing the highly sensory embodied experiences.

References

AC 2012. Aesthetic Computing 2012 Course. http://www.cise.ufl.edu/~fishwick/ac/2012/
ACP 2012. Aesthetic Computing Best Project Videos.
    http://www.cise.ufl.edu/~fishwick/ac/2012/bestproj.html
Fishwick, P. A. 2012. Aesthetic Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.).
    "Encyclopedia of Human-Computer Interaction". Aarhus, Denmark: The Interaction-
    Design.org Foundation. Available online at http://www.interaction-
    design.org/encyclopedia/aesthetic_computing.html
Malina, R. 2012. Commentary on: Fishwick, Paul A. (2012): Aesthetic Computing. In: Soegaard,
    Mads and Dam, Rikke Friis (eds.). "Encyclopedia of Human-Computer Interaction".
    Aarhus, Denmark: The Interaction-Design.org Foundation. Available online at
    http://www.interaction-design.org/encyclopedia/aesthetic_computing.html
Malina, R. and Strohecker, C. 2012. http://seadnetwork.wordpress.com/sead-white-papers-
    steering-committee/
Minecraft 2012. Redstone Circuits. http://www.minecraftwiki.net/wiki/Redstone_Circuits
Notch 2012. 0x10c Space Game Wiki. http://www.the0x10cwiki.net/0x10c_Wiki
Tadayon, R., R. Wilson, and P. Vo. 2012. Petri Nets in Minecraft. Accessed June 8, 2012.
    http://www.youtube.com/watch?v=sUR3xqPWU1I

Varela, F. J., Thompson, E. T., and Roach, E. 1992., The Embodied Mind: Cognitive Science and Human Experience, MIT Press.

Virtual Analog Computing, Fishwick, P., http://www.utdallas.edu/atec/docs/virtual-analog-computing.pdf

CoRE Challenges: the Artist in Residence Programme at the British Heart Foundation Centre for Research Excellence, Queens Medical Research Institute, University of Edinburgh

http://wp.me/P2oVig-n2

Coordinator: Chris Fremantle

Authors:
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Since 2009 the British Heart Foundation Centre of Research Excellence Award (BHF CoRE)[1] at the Queen's Medical Research Institute, University of Edinburgh, has worked with Edinburgh College of Art's Art, Space and Nature MFA[2] on a residency programme.

One of the aims of the BHF CoRE, in addition to biomedical research, is to increase public awareness in the area of cardiovascular disease and research being carried out in the Centre. The artist in residence programme is identified by the BHF CoRE as one medium for "bringing cardiovascular research to life," engaging with the public and encouraging young people in biomedical research. The BHF CoRE is one of three research centres making up the Queen's Medical Research Institute (QMRI).
The BHF CoRE was established in 2008 and is focused on four areas of cardiovascular research: Metabolic Risk Factors; Renal and Vascular Risk Factors; Vascular Injury, Inflammation and Repair; and Stem Cells. The Centre is led by Professor John Mullins, who is also the instigator of the artist in residence programme.

The Art, Space and Nature (ASN) MFA is an interdisciplinary project-driven programme established in 2002 within Edinburgh School of Architecture and Landscape Architecture (ESALA), Edinburgh College of Art. It attracts artists, architects and landscape architects interested in contextual practices. Donald Urquhart, Reader, ESALA, and Joint Programme Director, ASN, has collaborated with Prof. Mullins on the programming and delivery of the residencies.

The aim of this paper is to reflect on four years of residencies, focus on the opportunities and challenges of institutional partnership working and artists in residence as a model for connecting the art school with the biomedical research centre.

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[1] http://www.bhfcore.ed.ac.uk
[2] http://www.asnse.eca.ac.uk/

The first part of the paper sets out the programme outlining the selection process, who participated and what they did. The second part of the paper develops some of the issues based on email interviews with participants, including particular common experiences and challenges. The third part of the paper provides a theoretical 'side light' on the project drawn from Grant Kester's recent book *The One and the Many: Contemporary Collaborative Art in a Global Context* (2011). Kester is an art historian with a particular interest in collaborative and socially engaged practices. Finally we suggest future actions. This paper comes at the point where we are seeking new funding to take the programme of residencies forward.

To develop this paper we have asked each of the participating artists a few simple 'open' questions, "Why were you interested in a cross disciplinary collaborative project?", "What was the nature of the collaboration?", "How did you find it?" and "What assumptions became apparent in the process?". We asked a follow up question looking for comments or suggestions about areas for future work. The interviews were conducted by email. It was made clear to interviewees that their answers would be treated in confidence and that they would have the opportunity to see the way that their answers were used in the paper.

We can at this stage talk about sciart practices as a significant thread of the mid to late 20th century arts, and practitioners often trace a longer history (see for example Wilson's *Art + Science Now* (2010). There is considerable diversity captured by the label sciart, including individual projects and programmes developed by particular artists and scientists, as well as programmes, such as this one, involving multiple artists and scientists.

The context for the residencies is the biomedical research and its institution. The artists participating are registered on the Art, Space and Nature MFA, and are therefore at an early stage in their careers. The residencies are of between one and three months in duration, although some of the projects continued beyond this period as the artists produced the work. During the residency the artists have access to the BHF CoRE and visit on a regular basis. A number of the residencies have taken place outwith the semester cycle and the artists have been paid fees as well as expenses and production costs.

Selection Process

A consistent selection process, developed with the assistance of Art, Space and Nature staff, has been used for each of the three years of the programme.

All artists on the Art, Space and Nature programme were eligible to submit a proposal. All students attended a day of presentations at QMRI by given by a wide range of researchers.

In response there was a second day of reciprocal presentations by artists on the Art, Space and Nature programme. These covered their own practice to date and highlighted areas of research at QMRI that were of interest to them.

QMRI researchers along with Art, Space and Nature staff then made the final selection for two residencies, one for three months and a second for one month.

Residency Structure

Artists were inducted at QMRI and a work programme was agreed targeting contact with appropriate researchers.

For the longer residencies, artists spent the first month familiarising themselves with the specific research that was the focus of the proposal. The process of familiarisation was in each case a challenge, requiring the artist to gain an in-depth understanding of very specific areas of work. Some artists worked with only one researcher, whilst others worked with researchers across a number of specialisations. The artists needed to gain a sufficient understanding to be able to respond to the research and to develop work which represented the complexity whilst being engaging for a general public audience.

Residencies ended with presentations followed by Q&A sessions involving the wider group of researchers and artists.

Outputs and Outcomes

Art works produced on the residencies have been installed in the QMRI building. Two residencies have also produced digital art works for the BHF CoRE website[3].

Art works have also been shown in Art, Space and Nature's Tent Gallery (which faces onto West Port in the centre of Edinburgh), as well as in Ocean Terminal, a large shopping centre in Leith.

The programme is featured on the BHF CoRE website including documentation of the artists' work and background on their practice.
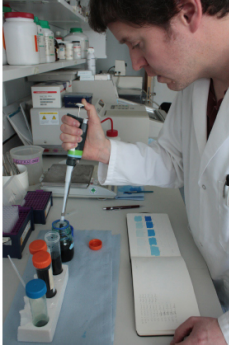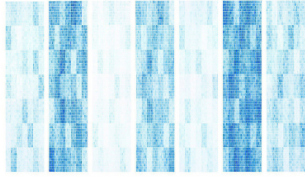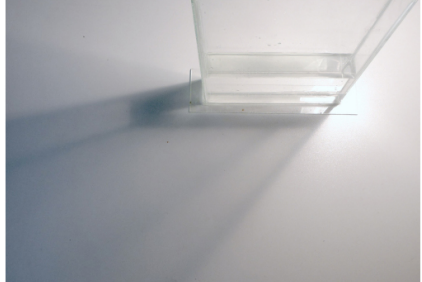
In the wider context Edinburgh has a thriving Science Festival[4] which has included art science cross over projects within its programme. There are a number of art science initiatives in Edinburgh including ASCUS,[5] Edinburgh Interdisciplinary Discussions,[6] and Synthetic
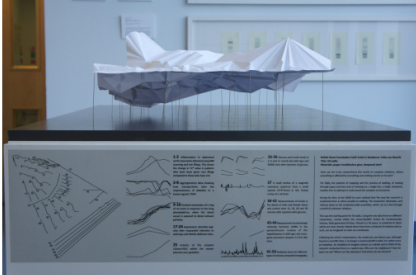
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[3] http://www.bhfcore.ed.ac.uk/artist_in_residence
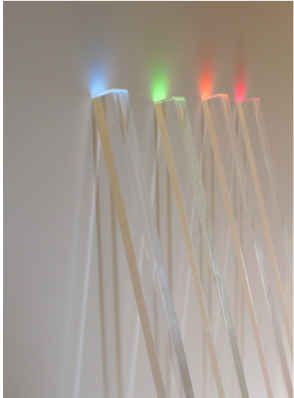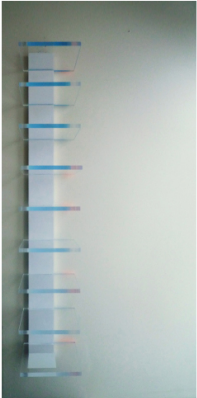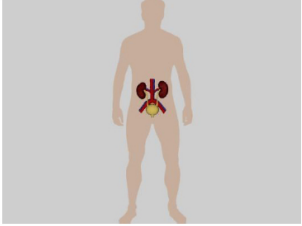[4] http://www.sciencefestival.co.uk
[5] http://www.ascus.org.uk
[6] http://www.eid.wikispaces.com
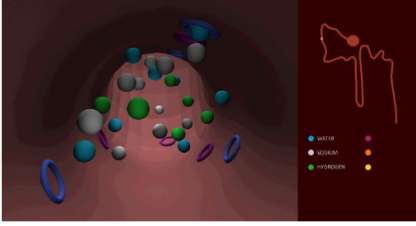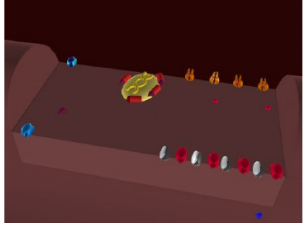
Mark Eischeid http://www.markeischeid.com/	Main Residency 2009	
The residency focused on questions of scale and complexity. The art work is based on interviews with over 30 researchers working throughout the BHF CoRE including biologists, physicists, and bioinformaticians.		
Colour mixing and testing for "Untitled" (2009)	"Untitled", watercolour (loading dye and water on paper), 108cm x 157cm, 2009	"Untitled", as installed at QMRI
Catriona Glover	Short Residency 2009	
QMRI_bookshelf: this image shows books from my own collection placed among the literature freely available to those in the canteen area. *The Poetics of Space* and *Water and Dreams,* both by Gaston Bachelard.	QMRI_window_cell: a pivotal image during the research process. The clouded grid represented to me a closed cell bundle as the usually transparent glass lets no exchange from the outside to the inside.	QMRI_single_cell_shadow: an early experiment into how best to describe my interpretation of the results of the interviews. This glass 'cell' is filled with water and casts a variable shadow. At this point I was exploring my understanding of an idea as a commodity. The ever-changing shadow illustrates an ethereal aspect of the way one can encounter a moment of understanding to find it, at the next moment, ungraspable.

Eddy van Mourik	Main Residency 2010	
The residency focused on the modelling of data derived from a number of areas of research at the BHF CoRE. The result of the residency was a piece, entitled 50 Walks, which represents the way in which a researcher works, eliminating possibilities and producing progressive comprehensible quantities that move a long a line. This results in lines of comprehension, running through a vast world of complexity.		
50 Walks		
Using the raw data from ten different researchers, mostly within the university/BHF Centre for Cardiovascular Science, van Mourik generated 50 lines. Placed in a 3d space, in proximity to those which are most closely related these lines form a network of relations and as such, can be imagined to make up a space, a landscape. Materials: Tempered steel, paper.		

Chandra Casali-Bell http://chandracasalibell.wordpress.com/	Main Residency 2011 Short Residency 2010	
The residency focused on the importance of light and colour in biomedical research focusing specifically on the identification of proteins, and in particular on Roger Tsien's fluorescent protein palette. She developed an art work *Untitled (Glow I)* installed in the building which draws out the way light animates colour, and a video piece which accompanies the work further exploring this theme.		
Untitled (Glow I)	Still from Video	Untitled (Glow II)

Sinéad Bracken http://www.sineadbracken.co.uk	Short Residency 2011 (ongoing Nov 2012)	
The residency focused on biological systems and their regulation of the movement of cells, hormones, chemicals and other processes in the human body. The artwork is an interactive animation of the Kidney to be used as a learning tool for the public and students. The piece identifies the structure of the kidney before focussing on a nephron, one of hundreds of thousands whose purpose is to filter the blood. What follows is a 3d visualisation that takes the viewer on a journey through the nephron from the perspective of a substance within the nephron. The piece shows the movement of water, sodium and hydrogen among others as they are absorbed from and secreted into the nephron depending on the body's needs. An additional animation highlights further processes within a collecting duct cell, situated on the wall of the nephron.		
Journey Through the Kidney (still from animation)	Journey Through the Nephron (still from animation)	Movement Within Cell, Wall of Collecting Duct, Nephron (still from animation)

Interviews

We have elected to make the interviews anonymous and simply refer to 'the artist'.

All of the artists responded to the questions posed by email. Of the biomedical researchers, only Prof. Mullins responded to the questions. He did comment that "I am afraid that people have a great antipathy for surveys..."

Prof Mullins offered three specific observations when asked the question "What assumptions became apparent?"

> That commonality of language was a challenge.

> That the concept would be universally popular (it also had a few detractors).

> That more senior scientists would be engaged in the programme (a few were, but the more junior researchers were more active).

It is hardly a revelation to say that language is one of the key challenges for interdisciplinary work. By its very nature working between disciplines involves negotiating between specialised terminologies. The artists on the ASN programme are by definition interested in interdisciplinary practice. Each artist who undertook the BHF CoRE residency described their interest differently.

(Each of the following paragraphs is a quote from a different artist-in-residence).

> My practice often centres around the flow of rhythms and patterns in various environments, and what factors are in place that restricts and dictates these movements. This investigation occurs on numerous scales. For instance, The design of road markings and their instruction of the movement of traffic. The idea

of going onto investigating movement on a microscopic level and how biological systems dictate the movement of cells, hormones, chemicals and other processes in the human body seemed incredibly interesting to me. Being able to work with people who are extremely knowledgeable and skilled within these areas would then provide me with a much greater understanding.

Every opportunity to meet with a different approach to understanding the world informs and challenges my own understanding. I want to know what everyone else thinks in order to understand what I think.

I had obviously rubbed shoulders with people from different disciplines throughout my career as a designer and artist, especially with people from the field of geography. But this simply resulted in "inspiration" e.g. shopping for ideas. These were then safely incorporated into my own work or used to contextualise it. … An actual collaboration across two very different disciplines, art and hard science, was a very serious endeavour to me. I am an artist with a very Beuysian belief in the emancipating power of art and I felt like this was a great opportunity to both learn and teach.

My academic and professional background is multidisciplinary, and it includes earth science, landscape architecture, and fine art. A large part of why I chose each of these fields is that each are inherently interdisciplinary, and this is true for why I was attracted to the Art Space + Nature programme. The BHF CoRE Artist-in-Residency provided a unique cross-disciplinary opportunity to continue a practice that had always seen the value in exploring the overlap between seemingly disparate fields.

I began working on collaborative projects during my undergraduate degree and enrolled on the ASN post-graduate programme because of its emphasis on cross disciplinary collaborative projects, as this is where my artistic interest lies. Working collaboratively, especially in a cross-disciplinary capacity, has an expansive function - enabling one to see outside of their own perspective. Both scientists and artists work with creative methodologies, with the studio and the lab being an environment of discovery and development - but they differ in purpose or intent.

The common thematic is the interest in and expectation of being challenged by a different discipline to achieve "greater understanding", "challenge my own understanding," "to both learn and teach", "exploring", "see outside their own perspective."

The complex reality of these ambitions particularly in the context of a residency is well articulated by one artist,
> My time at QMRI was a clumsy process of bumping into questions I hadn't expected and rules I didn't know exist, while creating a few obstacles of my own.

The challenges of specialist language, one of the mediums of engaging with other disciplines, was directly addressed in some of the interviews. One artist said in response to the question about assumptions,

> It became apparent to me that two people can use the same word to entirely different ends. Or that an Institute can use that word to a different end of the individual. I can clearly remember, in one interview, it dawning after 15 minutes that we faced a fundamental difference in each of our interpretations of the same conversation. That realisation has aided my approach in subsequent research.

Another artist, when asked about future development, directly addressed the structure of the residencies when they commented,

> Instead of having the single flow of information (scientist>artist) as it has happened thus for there should be the opportunity for the artist(s) to design meetings or workshops in which the artist can give input into the organisation and a more equal exchange can happen.

Their suggestion that there was a flow of information from scientists to artists is picked up by other artists, one of whom said, again in response to future development,

> ...this residency is asymmetric (it's not a true 50-50 collaboration), favouring the artist...

It is particularly interesting that this artist framed the flow of information in terms of favouring the artist. Whilst it is normally assumed that the artist is in the 'weaker' position, that science has the 'authority', the format of the residency and the role of the biomedical researchers as hosts, gives the artist the time and space to ask questions, find the locus of their own interests and develop artworks.

Conversely the artists were participating in the residencies as part of their work and studies whilst the biomedical researchers were contributing time. Engaging with the artists was not part of their work or studies and does not contribute to their career.

The importance of the role of the host in this sort of interdisciplinary programme was highlighted by the Artist Placement Group starting in the mid-60s. Their programme, first of placements in industry, and then in public services, is one of the prototypes for residencies. Barbara Steveni (2003), one of the founders of the Artist Placement Group, said about placements that they were,

> Constructed to traverse time, place and discipline, this method does not impose on any context, place or person, but rather suggests engagement between the artist on the one hand and invitation by the potential host on the other.

Steveni goes on to highlight several key factors identified by the Artist Placement Group including,

1. That the status of the artist within organisations must necessarily be in line with other professional persons, engaged within the organisation.

2. That the status of the artist within organisations is independent, bound by invitation (very important) rather than by instructions from authority within the organisations, department, company, to those of the long term objectives of the whole of society.

The Artist Placement Group also placed high value on the process by which the artist learns about the organisation, the context in which they will be working. Most of the artists described the process of getting to know the biomedical researchers through 'interviews'.

The interviewees made time to explain their work and offered inspiration whilst having no idea what would become of their contribution.

Another described their starting point as,

My Artist-in-Residency began with about 30 interviews with researchers throughout the CoRE over the course of a month. My goal was to get a sense of the range of research supported by CoRE, and to see if I could discover concepts that all the researchers shared.

They went on to further describe the process,

The interviews were informal and unstructured. My goal was to hear what their research was about. The only somewhat consistent question I asked was along the lines of "Why did you choose to pursue your field (science, cardiovascular research, etc.)?"

It is worth bearing in mind that each residency involved one artist working in an institution with some 150 biomedical researchers. Whilst the structure of the selection facilitated introductions, several of the artists sought, rather than focusing on a particular theme or specific area of work, to engage more broadly with the institutional context.

Within the programme there are three words, residency, commission and collaboration, being used which all imply slightly different processes within the visual arts.

Residency is usually used to describe a period where an artist is engaged in a specific context. Residencies range from having specific outputs to periods of self-directed investigation. A residency will usually be framed by a brief. The Artist Placement Group advocated having self-directed investigation as the starting point of a placement, and they termed this 'an open brief'.

Commission is used to describe the circumstances where an artist is paid to produce a piece of work by another party. The other party sets the 'brief' for the commission.

Collaboration is perhaps the most complex term. Collaboration most simply put means that two people are working together on something. It is therefore potentially relevant both to 'residency' and to 'commission.'

Within the BHF CoRE artist in residence programme all the artists were expected to produce one or more pieces of work. Some of these were self-directed results of the residency and others were more directed commissions.

The interview questions asked of the participants were framed in terms of an assumed interest in collaboration, but the actual responses suggest that collaboration should not be taken for granted, and that it was not the uniform experience.

One artist noted,

> There was consistent support from John [Prof. Mullins], and conversations with John throughout the project ended up being the most valuable and enjoyable interaction between myself and another scientist.

Another said in relation to future developments,

> In order to extend art-science collaboration, I think the process would be greatly enhanced and become more dynamic through greater engagement from the researchers. Rather than the artist learning from the biomedical researchers and seeking to interpret their work creatively, the collaboration could be a more mutual process where each party is taken out of their comfort zone and normal way of working to really understand the method and process of each field and bring something new to the other.

Within the discourse on artists and collaboration there is an assumed authenticity in collaborations where there is equality between the two disciplines that are working together, and further that the Being inspired by someone or something isn't the same as collaboration and true collaboration had only happened with other artists for me. These collaborations had often resulted in something that was completely new and different from what any of the artists had done before, a truly emergent piece of work.

They went on to say,

> I definitely tried, and had the help of a lot of people at the QMRI but ultimately I don't feel like a meeting of the minds in a productive and equal way was happening and I see the work as very much my own.

One of the key texts in the literature on collaborative practices, albeit focused on social projects is Grant Kester's The One and the Many, an in-depth inquiry and theorisation of a number of long term collaborative practices and projects in different parts of the world. Kester's text does

not assume that there is a thing such as an 'interdisciplinarian' as found in Repko (2008). Kester explores the practice of collaboration and draws theoretical conclusions. His focus is on the ontology of collaboration rather than it's epistemological construction. Whilst the artist in residence programme at the BHF CoRE is a different context from the social projects highlighted by Kester, there are useful points that can reveal a wider set of shared issues.

Kester's analysis of the collaborative methodology of long term projects, understood as work, is revealing,

> ...this is a labor that occurs through the thickly textured haptic and discursive exchanges that unfold in these projects over a period of months and even years. It is linked in turn with a cognitive movement, a reflective shuttling or oscillation, between contingency and freedom, figure and ground, immersion and distanciation, which generates new insight. (2011, p.101)

Kester highlights the need to understand the durational aspects of collaboration, as well as the dynamic of the work of collaboration, and for him the collaboration is the work, perhaps more than the product resulting from the collaboration. He highlights a dynamic of collaboration between artists and communities which requires both immersion, but also periodic 'stepping back'. In Kester's analysis collaboration is a not simply compromise or the discovery of a shared objective, but a process of development which is best understood as a cognitive process of stepping into and back from the context, the 'other'. This process has, for Kester, and for some of the artists interviewed, the potential to change both parties.

Kester goes on to say,

> In the most successful collaborative projects we encounter instead a pragmatic openness to site and situation, a willingness to engage with specific cultures and communities in a creative and improvisational manner … , a concern with non-hierarchical and participatory processes, and a critical and self-reflexive relationship to practice itself. Another important component is the desire to cultivate and enhance forms of solidarity... . (2011, p.125)

All the residencies undertaken to date have resulted in artworks, and those artworks now form part of the QMRI environment, in some cases physical and in some cases digital.

Work is currently on-going to extend the programme into a further period. Inevitably this requires securing new funding. Whilst most art science collaboration is project funded, and this is a challenge in itself, the challenges articulated by the artists in the responses to the questions are at least as important to the future development of this work.

1. Those managing the residency programme need to engage the biomedical researchers more
One challenge in the current configuration is that the residencies are relatively short and occur once per year. This may indicate a wider challenge in terms of building up a depth of work in across the disciplines which engages researchers and practitioners in both fields more effectively.

Suggested action: the team delivering the residency programme is exploring the possibility of introducing a collaborative PhD programme which could result in one or two artists working between the BHF CoRE and the ASN programme over a three to four year period. The existing structure of mutual introduction, open selection and hosting would then be supported. More generally it may be relevant to think in terms of multi-layered programmes and overlapping projects, rather than stand-alone initiatives.

The second challenge in the current configuration is focused on perceived value. The artist in residence programme has been funded as part of the BHF CoRE ambition "to bring cardiovascular research to life". The value articulated by the artists on the ASN programme is perhaps slightly different, being an opportunity to engage with researchers in a distinctly different field.

The arts certainly have communicative skills and potential (one of the artists ran graphic design workshops for the biomedical researchers to aid them with conference poster design).

The work of the artists in residence has contributed to changing the environment of QMRI. The installed artworks contribute to the environment of the building, which is otherwise highly institutional.

Suggested action: the articulation of the value of activities between artists and research scientists needs to grow a greater level of shared values, or mutually recognised values. There have been discussions around presenting both the artworks and the biomedical research, each in their own formats, rather than just presenting the artworks in exhibitions and installations. Perhaps greater solidarity, as suggested by Kester, could be important.

2. The institutions needs to unpack the idea of collaboration as a mode of practice. The current construction of collaboration within the arts is challenging within the context of interdisciplinary work, and there is a need to articulate more clearly a range of different forms of interaction between artists and, in this case, biomedical researchers. The biomedical researchers also use the terminology of collaborations.

Suggested action: examples and case studies of different forms of interdisciplinary practices need to be developed and be made available to broaden the understanding of forms of collaboration. Modes of collaboration in other disciplines need to be included within this process.

Note: ASN has secured internal University Challenge Funding for a programme of seminars involving key examples of durational and collaborative art-science projects. The seminars will further contextualise the BHF CoRE residency programme as well as explore the modalities of introducing a PhD thread into the programme. They will be documented to provide a resource for learning and teaching. This process of building networks will expand the idea of what constitutes art science practices.

References:

Casali-Bell, C. (2012). Untitled: Glow. Self published http://www.blurb.co.uk/books/3200007 accessed 16 November 2012.

Fremantle, C. (June 2012). Reflections on Collaboration. 24 August 2012. Newcastle: a-n The Artists Information Company. http://www.a-n.co.uk/publications/topic/2228109 accessed 19 November 2012.

Kester, G.. (2011) The One and the Many: Contemporary Collaborative Art in a Global Context. Durham and London: Duke University Press.

Klein, J.T. 'Unity of Knowledge and Transdisciplinarity: Contexts of Definition, Theory and the New Discourse of Problem Solving' in the Encyclopedia of Life Support Systems. Paris: UNESCO. http://greenplanet.eolss.net/EolssLogn/mss/C04/E6-49/E6-49-01/E6-49-01-TXT.aspx accessed 19 November 2012.

Repko, A.F. (2008). Interdisciplinary Research: Process and Theory. California, New Delhi, London, Singapore: Sage Publications.

Steveni, B. (2003). Repositioning Art in the Decision-Making Processes of Society in Artist as Educator, Interrupt Symposia. http://www.interrupt.org.uk/symposia/educator/repositioning-art/ accessed 15 November 2012.

Wilson, S. (2010). Art + Science Now: How scientific research and techological innovation are becoming key to 21st-century aesthetics. London: Thames & Hudson.

DIWO (Do-It-With-Others): Artistic Co-Creation as a Decentralized Method of Peer Empowerment in Today's Multitude

http://wp.me/P2oVig-hZ

Coordinator: Marc Garrett

Introduction

Furtherfield originally created the term DIWO in 2006, to represent and reflect its own involvement in a series of grass root explorations. These critical engagements shift curatorial and thematic power away from top-down initiations into co-produced, networked artistic activities; it is now an international movement and it has grown into something much larger than we imagined.

The practice of DIWO allows space for an openness where a rich mixing of components from different sources crossover and build a hybrid experience. It challenges and renegotiates the power roles between artists and curators. It brings all actors to the fore, artists become co-curators alongside the curators, and the curators themselves can also be co-creators. The 'source' materials are open to all; to remix, re-edit and redistribute, either within a particular DIWO event or project, or elsewhere. The process is as important as the outcome, forming relationally aware peer enactments. It is a living art, exploiting contemporary forms of digital and physical networks as a mode of open praxis, as in the Greek word for doing, and as in, doing it with others.

This study investigates why these critically engaged activities were (and are) thought of as essential nourishment not only for 'individual' artists, but also as an effective form of artistic collaboration with others, and to a wider culture. It explores the differences between 'collaborative' trends initiated by established art (mainstream art) and design institutions, the creative industries, corporations, and independent projects. It examines the grey areas of creative (idea) control, the nuances of power exchange and what this means for independent thinking artists and collectives working within collaborative contexts, socially, culturally and ethically. It also asks, whether new forms of DIWO can act as an inclusive commons. Whereby it consists of methods and values relating to ethical and ecological processes, as part of its artistic co-creation; whilst maintaining its original intentions as a decentralized method of peer empowerment in today's multitude?

DIWO and New Media Art Culture

"...the role of the artist today has to be to push back at existing infrastructures, claim agency and share the tools with others to reclaim, shape and hack these contexts in which culture is created." [1] (Catlow 2010)

In music and art culture, artists have been defining their autonomy against the dominance of mainstream culture for years. Furtherfield's and DIWO'S own history began with experimental sound and music, with pirate radio stations and collaborative street art projects in the late 80s and

early 90s. A Present-day example where we can see artists carving out their own mutual spaces of independence, is in the contemporary Indie Music scene. In her study 'Empire of Dirt: The Aesthetics and Rituals of British Indie Music (Music Culture)', Dr. Wendy Fonarow [2] investigated the UK's 'indie' music scene and its culture from the early 1990s to present day. Below, Fonarow presents the different values between mainstream music and the independent music scene.

```
INDIE                      MAINSTREAM

independent labels         major corporations
gigs                       stadiums
independent                centralized authority
local                      global
intimate                   distant
personal                   impersonal
simple production          elaborate production
no guitar solos            guitar solos
modest                     self-indulgent
live                       prefabricated
self-made                  other-made
authentic                  phony
original                   generic
specific                   general
lean                       fat
transit vans               tour buses
unprofessional             muso
raw                        slick
austere                    lavish
intelligent                insipid
substantive                empty
art                        commerce
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On the left side on the diagram there are similar themes and values DIWO also draws upon, as part of its grounded ideas and relational connections with others. DIWO as a practice is different than the Indie Music scene, yet its core values also involve self-governence. The Indie music scene views itself as oppositional to the mainstream music world, viewing it as "corpulent, unoriginal, impersonal, and unspecialized" [3]. Out of these shared values, vital signifiers are formed demonstrating peer empowerment. Like the tribal and anti-establishment elements of Punk, it is a deliberate side-step away from what is seen as the trappings of commercial culture, and its limitations on creative expression. The continuing growth and interest in independent music as it manages to survive seperately from the mainstream, is evident. We only have to view recent revenue making web sites such as emusic, with its international audiences buying Indie music and experimental sounds on-line; a good example of a grass root, networked economy based around social differences in contrast to mainstream dominance. The large site consists of an abundant amount of independent artists selling their work as well as independent record labels.

Even though the values presented by Fonarow also exist in DIWO. In essence, DIWO relates to a varied set of practices still finding its place in the world. This overall field is Media Art, an umbrella term for various 'art and technologically' related practices. Born out of art and electricity, it connects to common people through the Internet and as yet, not officially prescribed as a valid form of artistic expression by the art establishment (mainstream art world). Media Art's historical canons and critical dialogue; no matter how artful, highly skilled, informative, extravagant, original and critical; have been manipulated out of the 'official' picture. For years, Media art practice has found itself in the wilderness as wandering nomads, upstarts and outsiders. And even though much of the art work and its consistant and thriving dialogue is 'up to date' and contemporary; it is at odds with the mainstream world's prescribed script of what the dominating art market expects 'art' to be. Norman Klein, in his essay "Inside the Stomach of the dragon: The victory of the Entertainment Economy," writes "We all essentially live in the stomach of the 'entertainment' dragon. As a result, it would be near impossible to generate an avant-garde strategy in a world that feels increasingly like an outdoor shopping mall, what I call a scripted space." [4] (Klein 2005)

Media art certainly does not fit easily within Klein's description of 'scripted space'. One could also be forgiven for thinking it is perceived as too clever, or too cheeky for its own good. The field is always experimenting, adapting, re-inventing and expanding with a multitude of social and cultural narratives alongside its use of technology. [5] (Blais & Ippolito 2006). The general view is that it's just too complex and too fast for traditional art critics, galleries and institutions to catch up with. On some part, this is true - with its intrinsic connectedness, its 'fluent' networks – its multiple contexts - its critical, social and political dialogues - its adaptive behaviours when using code (an international language) - the ability to cross over into different practices, with verve. Yet, it is a contemporary art practice offering significant rewards when engaged with and explored further. Christiane Paul, in her essay "Challenges for a Ubiquitous Museum" writes, "Nethertheless, its integration is in museums' own best interest: new media art constitutes a contemporary artistic practice that institutions cannot afford to ignore. It can also expand its notion of what art is and can be." [6] (Paul 2008).

Arguably, it is the most 'contemporary' art practice. But, it still defies acceptance and dedicated integration from the mainstream art establishment. In September 2012, Claire Bishop wrote an article on Art Forum's web site, asking "WHATEVER HAPPENED TO DIGITAL ART?" [7] Bishop argues, there are no signs of digital art being represented in the contemporary art world by artists themselves, and asks why so few contemporary artists engage with "the question of what it means to think, see, and filter affect through the digital, [and] reflect deeply on how we experience, and are altered by, the digitization of our existence?" [ibid] Bishop says there seems to be a nostalgic nod by artists towards analogue technology "The continued prevalence of analog film reels and projected slides in the mainstream art world seems to say less about revolutionary aesthetics than it does about commercial viability." [ibid]

Bishop's article focuses on artists who do not engage with the questions she raises. By doing this Bishop introduces a telling blind spot; where there (really) should be a more in depth survey, analysis and discussion on the thriving discourse and practice of digital art and media art culture. Bishop bypasses, discussing the relevance of 'media art' as part of contemporary art culture, and

relegates it into what she terms as a 'specialist sphere'. Her distance from the 'actuality' of media art practice epitomizes a common failing where academics and critics, not directly engaged with the art they discuss, end up misrepresenting its deeper contexts and real values. This is noticeable when Bishop only includes commercially known artists, and not emerging media artists. An effective tactic in keeping others down whilst proclaiming there are 'no others', a highly effective mechanism exploited by the art elite. Whether Bishop is aware of this or not, the background story here is that thousands of artists and their livelihoods are threatened by ill-informed, perceptions. The result is that artistic emancipation is given a wide birth, or seen as a threat whilst authorized, and marketable art brands are given greater resonance and representation above others. The art elite, and its hierarchies dependent on their brands, stand strong against (other) art and is treated as a threat to their own, economic based franchises.

This is not to say those not included in Bishop's article are not seen by many others – thankfully, they are. If we move our (distracted) gaze away from (mainstream) art establishment eyes, a less restrictive vision begins to unfold. Artists, audiences, writers and curators engaged with media art culture are thriving and are gaining recognition and impetus, in spite of top-down, processes of commercialized, methods of filtering and institutionalized denial. Media art practice carries on regardless with its social and cultural diversity and its naturally transdisciplinary initiatives. Exploring beyond a 'scripted' art world and its reductive 'marketed' mythologies. The audience has played a significant role in bringing about this change. Everyday people are choosing to find their own examples of what they consider to be art, rather than just reading approved promotions by the mainstream art press. There are countless examples of contemporary, media art works being seen in galleries, on the Internet and different types of spaces, by artists such as, Annie Abrahams, Julian Oliver, Thomson and Craighead, Mary Flanagan, Genetic Moo, Kate Rich, Dominic Smith, Sarah Waterson, and Heath Bunting (the list goes on). All these artists are experiencing recognition as 'contemporary artists' in the 'wider' art world and extended, cultural communities.

"Museum curators are sometimes surprised to discover that more people surf prominent Internet art sites than attend their own brick-and-mortar museums." [8] (Jon Ippolito)
The strange contradiction of being told that something is different to what one actually knows through 'grounded' experience creates a situation of distrust. This awkward state of affairs brings to notice that other forces are at play. Pre-post-modern questions relating to 'authenticity' come to the fore; as well as critical enquiries asking, on whose 'authority' such decisions are made? Naturally, realisations escalate with concerns that art is rarely considered on its merits, and it is more about conforming to strategies in-line with top-down, market led appropriation, this is – what creates the divide. We are then left with an art culture where artists are merely consumer brands, representatives and ambassadors of conventional taste, no matter how radical the contemporary art world or academic wisdom tries to pretend it is. "The more art meets the demands of business, governments and the super-rich, the more the promise of that freedom falters." [9] (Stallabrass 2011)

This refusal of allowing other art for a more marketable set of franchises moves into totalitarian forms of enterprise, where production of culture is issued through mechanisms of marketing defaults rather than intuitive investigation and wider societal inclusion. We are presented with a spurious version of art-reality, a false consciousness dedicated to the embodiment of a class

where a filtering out of difference creates a homogeneity in which we are forced to see art much like merchandise in a shopping mall. Celebrity, genius and scarcity become the main selling points in established art venues and traditional art magazines. In America, individuals such as Cory Archangel are presented above others whilst those who openly critique culture in their art work are less recognised. Some may feel that it is a positive step that Archangel is currently successful in these institutional frameworks. That, if particular individuals are selected as worthy of mainstream acceptance and support it will have a 'Trickle Down' effect, where other artists will also be included and experience similar accolades in time, and "If the rich do well, benefits will "trickle down" to the rest." [10] (Blair)

But, what if these artists prefer by choice to be part of an art world less based on hegemony; and are more interested in being closely connected with their grass root art cultures, and are less interested in art celebrity culture? What if the art itself consists in its make-up similar values to those musicians in the Indie Music scene? What if this art is asking important questions that deserve a dialogue which goes deeper than marketable products, and proposed celebrity genius? Gregory Sholette explores this subject further in his book "Dark Matter: Art and Politics in the Age of Enterprise Culture" [11], proposing that art thrives in the independent and non-commercial sectors and the material produced by unrepresented artists, feeds the mainstream to sustain a few artists within the art world elite. He sees those 'left out' of the branding exercises prescribed by the corporate run, contemporary art world, as 'Dark Matter'. Sholette borrows the term "Dark Matter" from the science of cosmology, which refers to the immense quantity of non-reflective material that we cannot see out there, in the universe. In theory, this invisible matter makes up most of the universe, and is estimated to constitute 84% of the universe and 23% of it is mass energy. [12] (Hinshaw 2010) "Like its astronomical cousin, artistic Dark Matter makes up most of the cultural universe in contemporary, post-industrial society. Yet, while cosmic Dark Matter is actively being sought by scientists, the size and composition of artistic Dark Matter is of little interest to the men, women and institutions of the art world." [13] (Sholette 2011)

Media Art, can be considered to be a part of this Dark Matter. Yet, there are examples where artists using technology have found ways to survive using their technical skills, by becoming innovative. This ambigious territory of artists moving into the creative industry field, where artists act as entrepreneurs, is complex and based on survival. Because the mainstream art world has not given these artists the overall recognition in an uncertain world from suffering recession, unless your lucky enough to be some of the few receiving an inherited income, survival is the main issue. The powers of neoliberalism continue to advocate a program of mass privatisation, deregulation, and marketisation, and the breaking down of educational funding world wide, producing mass global and local poverty. "Meanwhile, the same system imprisons everyone's creativity in the prism of brutal economic "necessity." Today's Van Goghs are working at McDonalds. Tomorrow's Mary Shelleys are graduating owing a fortune in student loans." [14] (Haiven 2012)

There is a demand for artists to introduce themselves as 'New', and 'exciting', as technicians feeding the creative economy, as in what Haiven terms as 'creative capitalism'. In part, it creates extra confusion for media art culture, which has helped in the establishing a schizm, the term 'New Media Art'. And yes, technology combines all of these different digital art processes and its ever widening, interrelated disciplines. Yet, when using a simple word such as 'New', it

proposes as part of its meaning that it's all about the 'New', as in, use of 'New technology' as an outright goal or a means to an end. This is a misleading term, and does not acurately reflect a field of practice incorporating crossovers and transdisciplinary understandings, uniting our engagement and experimentation with technology at a 'variety of levels', which also include ecological tendencies as well as social interpretations. Out of this, arrives a filtering process whereby assumptions and prescribed definitions reflect upon those who pragmatically abide with the dominating rules, or just so happen to fit into this reductionist gauge. In one sense, this relates to a form of top-down 'cultural' curating and then moves into other modes of standardization, initializing 'extra-loaded' mono-cultural themes prompting domination. This instigates conditions where on the whole artists working with technology become valued not because of their content or ideas, but mainly by the technological innovation itself.

And yes, innovation and invention is an imaginative means to explore, proceed and develop as a race. But, innovation as technology is 'one' factor, a segment which all too often distracts us from a bigger story. Emphasis on the 'New' bound up with 'innovation' falls into a paradox where technological determinism, 'is' the course of reason, fitting closely alongside an invasive, market driven ideology. The values then become purely measured by economics as a finite, a singular function that belies the intricacies of the ecologies needing attention within the art's wider multi-relational contexts. Andrew Feenberg in his paper "Ten paradoxes of Technology" writes "Under capitalism control of technology is no longer in the hands of craftsmen but is transferred to the owners of enterprise and their agents. Capitalist enterprise is unusual among social institutions in having a very narrow goal—profit—and the freedom to pursue that goal without regard for consequences." [15] (Feenberg 2010)

The Media Art field's use of open networks has introduced an autonomy that has brought about a deeper understanding of the medium, and how to exploit it creatively. Appropriation of the software and the hardware has shaped how artists interact with each other. Peer critique and shared ownership of ideas have enabled small groups and communities to learn and initiate projects together. These networks have worked as doorways to connect people with other cultures, outside of their own nation states, museums, institutions and government focused ideologies. A constant dialogue and the swapping of knowledge, files and projects, peer collaboration, all nurtured by curiosity, generosity and shared interests. This has loosened the hard-edged, fabric of centralization.

A willingness to transform our ideas and intentions not soley based on 'proprietorial' dependencies, and a fetish for the 'New', allows space for 'different versions of the new' and 'old' dialogues to evolve. This enables the embracing of holistic gradations and interactions with others, which also include differences; possibilities and diversities connecting with ecology and a variant of creative expressions. James Wallbank in his essay for ISEA in 2010 wrote "Creativity transforms value. Defining a four-year-old computer as "obsolete" does not speak to the utility of the object (it's still a powerful production and communications platform) but indicates its user's unwillingness or inability to continue to be creative with it." [16] (Wallbank 2010) Taking control of the media we use does not mean being buying the latest gadget, it means that we are aware of our responsibility to be more informed about the technology we use.

In his article "Open Source Art Again", Rob Myers writes "Software is used to achieve many different ends within pluralistic society. Its use is as widespread and diverse as the written word was following the invention of the printing press. Free Software can therefore be understood historically and ethically as the defence of pluralistic freedom against a genuine threat. It is an ethical issue, a matter of freedom. This is very different from being a new method of organization or a more efficient means of production." [17] (Myers 2006) Control over one's tools of creative production is now, as significant as having control over one's creative ideas. And, media art as an art practice, has gained various attributes which allow processes of self-autonomy. There is something about working with technology and the Internet that changes our perception of the world, and how we operate in it. The world becomes less definable as nations and states. It evolves into a way of engaging and understanding other things, other worlds, other possibilities; touching on aspects of being able to re-edit 'source' materials, whether it be hardware, software or code, and bringing this knowledge with its learned experiences into, real-life situations.

DIWO History and its Context

Within media art culture, DIWO has cultural and historical links with Net Art and Tactical Media. DIWO includes other influences, such as Fluxus and Situationism. It owes much of its awkwardness and anti-establishment values to one particular movement in music culture, which is punk, drawing upon its D.I.Y attitude as inspiration. DIWO is playful re-interpretation and fruition of some of the principles, and reasons why Furtherfield was originally founded, back in 96-97. We experienced first-hand, as artists in the 80s and well into the 90s, a UK art culture mainly dominated by the marketing strategies of Saatchi and Saatchi. Even now, British art culture is dominated by and large, a commercially orientated, uncritical and non-reflective hegemony. Inequalities and gate-keeping are a standard behaviour, justified by spurious and romantic notions of genius, within tightly controlled, mono-cultural frameworks.

"Furtherfield's roots extend back through the resurgence of the national art market in the 1980s, to the angry reactions against Thatcher and Major's Britain, to the incandescence of France in May 1968, and back again to earlier intercontinental dialogues connecting artists, musicians, writers, and audiences co-creating "intermedial" experiences." [18] (da Rimini 2010)

When examining these hierarchies we notice the social divisions are a throw back from a very traditional period of British culture; bound in a colonial history of nationalism and imperialism. Of course, such historical traits are not bound only within the borders of the United Kingdom. It took an insightful American, John Dewey, who in spring 1932 gave a series of lectures at Harvard University, on the Philosophy of Art, to open up this issue. Out of these lectures grew his 1934 publication Art as Experience. He says "It erects these buildings and collects their contents as it now builds a cathedral. These things reflect and establish superior cultural status, while their segregation from the common life reflects the fact that they are not part of a native and spontaneous culture." [19] (Dewey 1934)

"From adolescence I had visited the Tate, read the Art books and generally pulled a forelock in the direction of the cult of genius, on cue relegating my own creativity to the Victorian image of the rabid dog. We know well enough that this was how it was supposed to be. The historical

literature on 'rational recreations' states that, in reforming opinion, museums were envisaged as a means of exposing the working classes to the improving mental influence of middle class culture. I was being innoculated for the cultural health of the nation." [20] (Harwood 2012)

In 2001, Graham Harwood [21] received the first online commission from Tate Gallery London for the art work "Uncomfortable Proximity". "This work forced me into an uncomfortable proximity with the economic and social elite's use of aesthetics in their ascendancy to power and what this means in my own work on the internet." [22] (Harwood 2006) The first section of work maps high society rituals of tastefulness and its inherent hypocrisy. The second, representations and histories of different people such as friends, family and others, who are unseen in terms of the institution's remit of tastefulness. To do this he used the historically respected paintings (on-line images) on the Tate web site by artists such as Turner, Hogarth, Hamilton, Gainsborough, Constable and others.
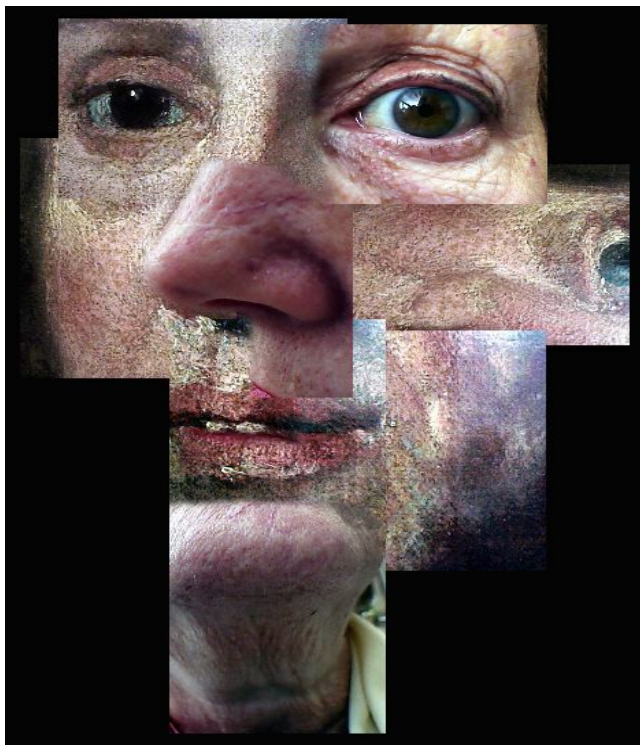

Graham Harwood. Hogarth, My Mum 1700-2000.

Viewing the visual images/collages created by Harwood, reminds one of the moment when Lord Henry, in Oscar Wilde's 'The Picture of Dorian Gray'[23] views his constantly changing, disfigured self portrait. The facade of greatness is revealed to be less attractive, less honourable and deeply disturbing. Harwood's approach in offering the viewer to click on the image to see what lies them behind shows the people he represents, to be seen as lurking secrets, as ghosts, mutants, lepers and outsiders. "Tate Britain stands on the site of Millbank penitentiary incorporating part of the prison within its own structure. The bodies of many of the inmates remain concreted into the foundations of the building. The drains that run from the building to the Thames, a stones through away, bleed this decay into the silt of the Thames." [24] (Harwood 2006)

Dewey's writings and Harwood's art work "Uncomfortable Proximity", explore how we are still governed by the same elite structures, informing (or appropriating) our perceptions and engagement in art culture today. DIWO's intentions reflect Furtherfield's own critical and practicle approach, in challenging aspects of art culture where false credence is given to a few individuals over many others, which is usually based either on personality alongside depoliticized artworks. Recently, in an article by John A. Walker on the artdesigncafé web site, discussed how art culture is still haunted by the power of Charles Saatchi.

"Arguably, as an art collector Charles Saatchi has become a brand in his own right—when he buys art works they and the artists who created them are immediately branded." [25] *(Walker 2010)*
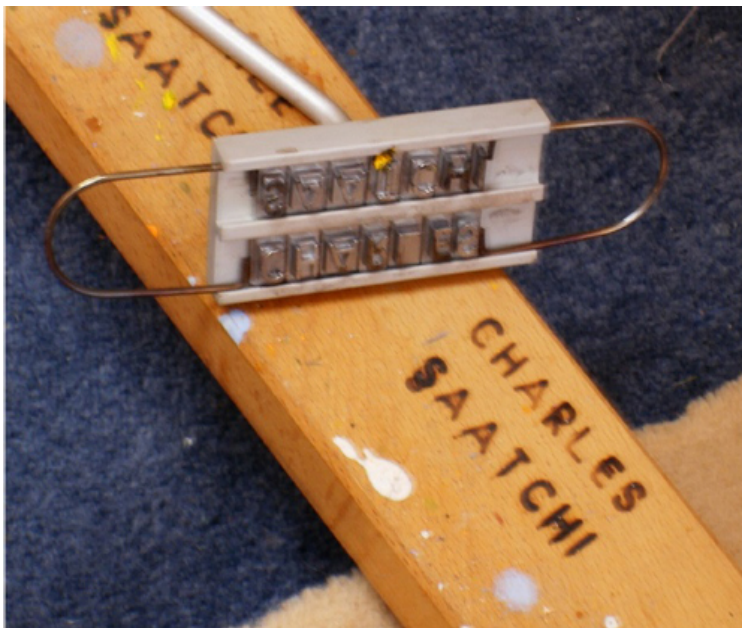
The Charles Saatchi branding iron is a limited edition work of art conceived by John A Walker.

BritArt's dominance of the late 80s and 90s UK art culture dis-empowered the majority of British artists, dominating other artistic discourse and fuelling a competitive and divisive attitude for a shrinking public platform for the representation of their own highly marketed work. This resulted in many artists replicating this art in order to be accepted into mainstream galleries and art magazines. This tactic of domination through market forces and elite friends in high places created what we know as BritArt. Stewart Home proposes that the YBA movement's evolving presence in art culture fits within the discourse of totalitarian art.

"The cult of the personality is, of course, a central element in all totalitarian art. While both fascism and democracy are variants on the capitalist mode of economic organisation, the former adopts the political orator as its exalted embodiment of the 'great man,' while the latter opts for the artist. This distinction is crucial if one is to understand how the yBa is situated within the evolving discourse of totalitarian art." [26] *(Home 1996)*

Whoever controls our art - controls our connection, relationship and imaginative experience and our discourse around it. The frameworks and conditions where art is accessed, seen and discussed are significantly linked to representation and ownership. Socially and culturally, this process of abiding by specific rules and protocols, defines who and what is worth consideration and acceptance. For art to be accepted within these 'traditional' frameworks a dialogue reflecting its status around a particular type of function kicks into place, it must adhere to certain requirements. Whether it is technological or using traditional skills (which may not necessarily be digital) the art or artist must in some way conform to specific protocols before it can be allowed into the outer regions of officially condoned culture. This process adds merit to the creative venture itself and feeds a systemic demand based around innovation in a competitive marketplace. This closes down possibilities for a wider, creative dialogue. When we experiment beyond the limits of assumed notions of 'excellence' or 'genius', and challenge the mechanisms and mannerisms of mainstream culture and its dominant values something else emerges and evolves, an imaginative exploration of engagement opens up new forms of art, but also new, shared, connected and potentially critically informed values.

The term DIWO OR D.I.W.O, "Do It With Others" was created in 2006 [27] (Garrett 2006), on Furtherfield's collaborative project 'Rosalind'. [28] An upstart new media art lexicon that Furtherfield built with others, born in 2004.

"(or Diwo's, or Diwo groups) Expanded from the original term known as D.I.Y. (Do It Yourself). D.I.W.O 'Do It With Others'. Is more representative of contemporary, collaborative - art practice which explores through the creative process of using networks, in a collective manner." (Garrett ibid)

DIWO (Do It With Others) is inspired by DIY culture and cultural (or social) hacking. Extending the DIY ethos with a fluid mix of early net art, Fluxus antics, Situationism and tactical media manoeuvres (motivated by curiosity, activism and precision) towards a more collaborative approach. Peers connect, communicate and collaborate, creating controversies, structures and a shared grass roots culture, through both digital online networks and physical environments. Influenced by Mail Art projects of the 60s, 70s and 80s demonstrated by Fluxus artists' with a common disregard for the distinctions of 'high' and 'low' art.

The Mail Art Connection & DIWO's Infrastructural Tendencies.

"It is in the use of the postal system, of artists' stamps and of the rubber stamp that Nouveaux Realisme made the first gestures toward correspondence art and toward mail art." [29] (Friedman 1995)

Mail Art is a useful way to bypass curatorial restrictions for an imaginative exchange on your own terms. With DIWO projects we've used both email and snail mail. Later, we will return to the subject of email art and how it has been used for collective distribution and collaborative art activities; but also, how it can act as a collaborative, remixing function or tool, and be an art piece in its own right, on-line and in physical environments.

"[...] many Fluxus works were designed specifically for use in the post and so the true birth of correspondence art can arguably be attributed to Fluxus artists." [30] (Blah Mail Art Library)

Many consider George Maciunas was to Fluxus, what Guy Debord was to Situationism. Maciunas set up the first Fluxus Festival in Weisbaden in Germany, 1962. In 1963, he wrote the Fluxus Manifesto in 1963 as a fight against traditional and Establishment art movements. In a conversation with Yoko Ono in 1961, they discussed the term and meaning of Fluxus. Showing Ono the word from a large dictionary he pointed to 'flushing'.

""Like toilet flushing!" he said laughing, thinking it was a good name for the movement. "This is the name", he said. I just shrugged my shoulders in my mind." [31] (Ono 2008)

"The purpose of mail art, an activity shared by many artists throughout the world, is to establish an aesthetical communication between artists and common people in every corner of the globe, to divulge their work outside the structures of the art market and outside the traditional venues and institutions: a free communication in which words and signs, texts and colours act like instruments for a direct and immediate interaction." [32] (Parmesani 1977)

Maciunas's ambitions were strongly based on an art that was free for all by replacing it with Fluxus; a creativity which could be realised anywhere and anyhow. Art with autonomy was the whole point of Fluxus, to "promote a revolutionary flood and tide in art, promote living art, anti-art". [33] (Corris 2009) Maciunas's refusal to have any Fluxus works signed was a critique on the concept of genius, scarcity and ownership. This made things difficult for dealers and collectors to brand the works in accordance to 'genius' and 'personality' for economic value; they were gifts, acts of imaginative generosity. These acts of generosity were part of a broader critique of capitalism during the 60s and 70s, they were gifts of resistance.

DIWO is a gift of resistance in the 21st Century, exploring relational and hybrical realizations. It is socially informed, constantly adapting, intuitive and grounded. It can collide with mainstream culture but also exist deeper in the networked shadows, in accordance to the needs of who ever participates at any given time. It is creativity with a radical adge, asking questions through peer engagement, as it loosens up infrastructural ties and frameworks. It is a contemporary way of collaborating and exploiting the advantages of living in the Internet age. By drawing on past experiences with pirate radio, historical inspirations from Punk, with its productive move towards independent and grass roots music culture, as well as learning from Fluxus and the Situationists, and peer 2 peer methodologies; we transform ourselves into being closer to a more inclusive commons. We transform our relationship with art and with others into a situation of shared legacy and possible moments of active emancipation.

"[...] art has become too narcissistic and self-referential and divorced from social life. I see a new form of participatory art emerging, in which artists engage with communities and their concerns, and explore issues with their added aesthetic concerns" [34] (Bauwens 2010)

The infrastructural tendencies that occur when 'the many' practice DIWO; informs us we are in a constant process which redefines the role of the individual, and our notions of centralized power and behaviour. This process also reevaluates concepts of art as scarcity. It moves us away from

an attachment with socially engineered dependencies, usually centred around consumer led desire, by changing the defaults. If we change the defaults we change the rules, opening up possibilities for more agency involving relational contexts.

"The network is designed to withstand almost any degree of destruction to individual components without loss of end-to-end communications. Since each computer could be connected to one or more other computers, Baran assumed that any link of the network could fail at any time, and the network therefore had no central control or administration (see the lower scheme)." [35] (Dalakov 2011)

Even though the Web and DIWO possess different qualities they are both essentially, forms of networked commons. They both belong to the same digital complexity, each are open systems for human and technological engagement. DIWO rests naturally within these frameworks much like other digital art works or platforms but have key differences. If we consider the structures of Facebook, Google, MySpace, iTunes and now Delicious, they are all centralized meta-platforms, appropriating as much users as possible to repeatedly return to the same place. In contrast to the original function and freedom of the Internet and its seemingly infinite networked nature, these meta-platforms are closed systems. Not, necessarily closed as in meaning 'you cannot come in', but closed to others in respect of core values, exploiting human interaction and their uploaded material, and openly 'given' data-information. These centralized meta-platforms close choices down through rules of ownership of personal data, as well as introducing more traditional standards of hierarchy.

Richard Barbrook and Andy Cameron saw this curious dichotomy way back in 1995. Where on one hand we had the dynamic energy of sixties libertarian idealism and then on the other, a powerful hyper-capitalist drive, Barbrook and Cameron termed this contradiction as 'The Californian Ideology'. "Across the world, the Californian Ideology has been embraced as an optimistic and emancipatory form of technological determinism. Yet, this utopian fantasy of the West Coast depends upon its blindness towards - and dependence on - the social and racial polarisation of the society from which it was born. Despite its radical rhetoric, the Californian Ideology is ultimately pessimistic about real social change." [36] (Barbrook and Cameron 1995)

With these contexts in mind DIWO, is not an absolute 'technological determined' factor, but a thing of many things, a social activism with a commons spirit going as far back as The Diggers.

"The Diggers [or 'True Levellers'] were led by William Everard who had served in the New Model Army. As the name implies, the diggers aimed to use the earth to reclaim the freedom that they felt had been lost partly through the Norman Conquest; by seizing the land and owning it 'in common' they would challenge what they considered to be the slavery of property. They were opposed to the use of force and believed that they could create a classless society simply through seizing land and holding it in the 'common good'." [37] (Fox)

Three elements pull DIWO together as a functioning whole, and it can mutate according to a theme, situation or project. These three contemporary forms of (potential) commons mainly include; the ecological - the social - and the networks we use. By appropriating these three 'possible' processes of being with others; combined, they introduce and enhance potential for an

autonomous and artistic process to thrive, further than the limitations of any single or centralized point of presence. It brings about small societal change; as long as we are conscious of the social nuances for a genuine and critically engaged mutual collaboration.

"Collective doings are motors of change transforming how people create (art, software, learning situations, community gardens, journalism) until the point that solitary production seems anachronistic and somewhat joyless. These motors can drive more radical change, as people collectively place their bodies into contested zones (reclaiming the streets, university occupations, climate camps) forcing struggles into public awareness." [38] (da Rimini 2010)

DIWO works by the same principles functionally as a p2p infrastructure, and requires the following "set of political, practical, social, ethical and cultural qualities: distribution of governance and access to the productive tools that comprise the 'fixed' capital of the age (e.g.: computing devices); information and communication systems which allow for autonomous communication in many media (text, image, sound) between cooperating agents; software for autonomous global cooperation (wikis, blogs etc); legal infrastructure that enables the creation and protection of use value and, crucially to Bauwens's p2p alternatives project, protects it from private appropriation; and, finally, the mass diffusion of human intellect through interaction with different ways of feeling, being, knowing and exposure to different value constellations." [39] (Garrett and Catlow 2012)

"Online creation communities could be seen as a sign of reinforcement of the role of civil society and make the space of the public debate more participative. In this regard, the Internet has been seen as a medium capable of fostering new public spheres since it disseminates alternative information and creates alternative (semi) public spaces for discussion." [40] (Morell 2009)

Ecological media artworks turn our attention as creators, viewers and participants to connectedness and free interplay between (human and non-human) entities and conditions. The foundations of the Do It With Others art context, that privileges FLOSS skills sharing and commons-based peer produced artworks and media over the monitored and centrally owned and controlled interfaces of corporate owned social media. This is the spirit of DIWO, if it's centralized and controlled by a corporate entity, it ain't DIWO.

Suggested Action

Art organizations, museums and art magazines should promote contemporary media art culture. Inivite emerging artists, art groups to talk about their work. Invite media arts practioners, theorists, organizations and communities to share their skills, knowledge and expertise. This includes national arts institutions, regional arts venues, mainstream art magazines and critical art magazines.

Barrier: Mainstream art world culture is currently biased towards the values of the powerful, whether it is institutional power or economic power. It's evidenced through the tight networks of media, international art markets and corporate sponsorship, and national insitutions. These act as constraints on the resources, ideas, platforms, ethics, aesthetics and technological engagements

of a wider and contemporary culture, and also restricts 'possible' connections and exchanges between artists and audiences.

Target (stakeholders): Art organizations, Museums, Galleries, Funding groups, Sponsors, Applied Research Funders, Universities.

Solution: Go and see the work created by contemporary media artists and look at the different sets of values found in their works, tools and processes and allow their artworks to define current trends, ideas and values, and contemporary art contexts. Look at web sites and on-line portals where these art communities are sharing dialogue around their works and the theories being discussed. Visit sites where critics and artists write on the subject of media art and related practices.

Extra Suggested Actions

1. Art organizations, museums and art magazines, and art institutions should engage in open investigations into grass root initiatives by D.I.Y, DIWO (Do It With Others), and Peer 2 Peer groups. Study their works, support and promote them as part of their artistic programs. They should also invest in the development of these projects (commissions, residencies, conferences, exhibitions and work shops etc). This will decentralize art culture and meet diverse audiences and communties on their own ground. It will also help them to learn about and appreciate the values and benefits of this important work being produced.

2. Make available for distribution at gallery bookshops and art and esign colleges, works currently being explored and written by theorists and artists writing about Media Art, this includes software art, art and hacktivism, psychogeography, net art, networked art, game art, glitch art, grassroots artistic innovation, interdisciplinary practices and contemporary forms of art dealing with technology, ecology, and free and open source technology.

3. Government funding agencies, development agencies and policy makers, local and national cultural policy makers, should give their support to ideas around alternative and mixed economies. And connect with artists and arts groups who are working with D.I.Y, DIWO (Do It With Others), and Peer 2 Peer projects. These are dedicated and informed groups creating new forms of shared commons as innovation, concerning climate change and the current economic crisis. Many of these groups are successfully exploiting the technological resources of alternative hardware and software, as part of a growing free and open source movement. Code and art are both international languages, where much of the most exciting and imaginative projects are being explored collaboratively. Jobs, funding and research into these areas will provide a more sustainable culture where groups involved in these practices can produce accessable and inclusive resources for artists, designers, ecologists, students and the public. They can also provide data and case studies for academic research.

References

[1] Can Art do Technology and Social Change? Ruth Catlow. October 2010.
http://www.axisweb.org/dlForum.aspx?ESSAYID=18115

 [2] Wendy Fonarow, PhD, is a Los Angeles based Anthropologist specializing in live music, ritual, and performance. Her expertise is in the area of the culture of indie music and American holidays. She is an Associate Professor of Cultural Anthropology at Glendale College. http://www.indiegoddess.com/

 [3] Empire of Dirt: The Aesthetics and Rituals of British Indie Music (Music Culture). Dr. Wendy Fonarow. Wesleyan; annotated edition edition (July 10, 2006) P66-67.

[4] Norman Klein. "Inside the Stomach of the Dragon: The Victory of the Entertainment Economy". In Eyebeam Journal: Dissecting Art and Technology (January 2005). http://www.eyebeam.org/reblog/journal/archives/2005/01/inside_the_stomach_of_the_dragon.html (web page now missing).

[5] At the Edge of Art. Joline Blais , Jon Ippolito. Thames & Hudson (Mar 2006).

[6] Christiane Paul. Challenges For a Ubiquitous Museum: From White Cube to The Black Box and Beyond. New Media in the White Cube and Beyond: Curatorial Models for Digital Art. Christiane Paul (Editor). (2008) P. 74.

[7] DIGITAL DIVIDE: Claire Bishop On Contemporay Art And New Media.
http://artforum.com/inprint/issue=201207&id=31944

[8] Jon Ippolito. Ten Myths of Internet Art.
http://www.nydigitalsalon.org/10/essay.php?essay=6

[9] Julian Stallabrass. Contemporary Art's Pyrrhic Triumph. 'The Hollow Triumph of Contemporary Art', The Art Newspaper Magazine, June 2011, pp. 7-8.

[10] Trickle-down Economics and Ronald Reagan. Jim Blair (last visited 25/9/12)
http://www.bigissueground.com/politics/blair-trickledownreagan.shtml

 [11] Gregory Sholette. Dark Matter: Art and Politics in the Age of Enterprise Culture. Pluto Press (January 4, 2011)

 [12] Hinshaw, G. F. (29 January 2010). "What is the universe made of?". Universe 101. NASA/GSFC. Retrieved 2010-03-17.

[13] Gregory Sholette. Dark Matter: Art and Politics in the Age of Enterprise Culture. Pluto Press (January 4, 2011)

[14] Privatizing creativity: the ruse of creative capitalism. Max Haiven on October 10, 2012.
http://artthreat.net/2012/10/privatizing-creativity/

[15] Andrew Feenberg. "Ten Paradoxes of Technology," Technē, vol. 14, no. 1, 2010. (Last viewed 01/09/2012) http://www.sfu.ca/~andrewf/paradoxes.pdf

[16] Life on the Trailing Edge: Ten Years Exploring Trash Technology. James Wallbank. (2010). (Last visited Aug 2012) http://www.isea2010ruhr.org/de/conference/tuesday-24-august-2010-dortmund/p17-media-politics-of-the-local#Wallbank

[17] Open Source Art. Rob Myers. September 2006.
https://github.com/robmyers/open_source_art

[18] Francesca da Rimini. Socialised Technologies, Cultural Activism, and the Production of Agency. Doctor of Philosophy in Humanities and Social Sciences 2010. P 194.

[19] Art as Experience John Dewey. Perigee Books (24 Sep 2009) P.336

[20] Graham Harwood. http://www.gold.ac.uk/cultural-studies/staff/g-harwood/

[21] http://www2.tate.org.uk/netart/mongrel/collections/default.htm

[22] Tate BricABrac. Graham Harwood. http://mongrel.org.uk/node/14

[23] The Project Gutenberg EBook of The Picture of Dorian Gray, by Oscar Wilde.
http://www.gutenberg.org/cache/epub/174/pg174.txt

[24] Museums and Prisons. Graham Harwood. http://mongrel.org.uk/node/9

[25] Charles Saatchi branding iron : Order now! "You are nobody in contemporary art until you
    have been branded." John A. Walker. September 2010
    http://www.artdesigncafe.com/Charles-Saatchi-brand-iron-Walker

[26] THE ART OF CHAUVINISM IN BRITAIN AND FRANCE by Stewart Home. Published
    in everything # 19, London May 1996. (Last checked 30th Oct 2011).
    http://www.stewarthomesociety.org/2art.html

[27] DIWO term on Rosalind By Marc Garrett - 08/11/2006
http://www.furtherfield.org/lexicon/diwo

[28] Rosalind, an upstart new media art lexicon, born in 2004.
http://www.furtherfield.org/get-involved/lexicon

[29] Friedman, Ken. 1995. "The Early Days of Mail Art: An Historical Overview." In Eternal
    Network. A Mail Art Anthology. Chuck Welch, editor. Calgary, Alberta: University of
    Calgary Press. Pp. 3-16.

[29] Artist of the week 26: George Maciunas. Jessica Lack. Last visited 20th Aug 2012.

[30] BLAH LIBRARY: IDENTITY IN THE ETERNAL NETWORK.
http://reocities.com/soho/5921/identity.html

[31] SUMMER OF 1961 by Yoko Ono. April
    2008.http://www.flickr.com/photos/yokoonoofficial/2892211895/#

[32] Loredana Parmesani, text under the entry "Poesia visiva", in "L'arte del secolo - Movimenti,
    teorie, scuole e tendenze 1900-2000", Giò Marconi - Skira, Milan 1997

[33] Michael Corris. Fluxus. From Grove Art Online © 2009 Oxford University Press.
http://www.moma.org/collection/theme.php?theme_id=10457

[34] An interview with Michel Bauwens founder of Foundation for P2P Alternatives.
    Furtherfield. By Lawrence Bird 2010.
http://www.furtherfield.org/interviews/interview-michel-bauwens-founder-foundation-p2p-
    alternatives

[35] Georgi Dalakov. "Paul Baran". History of Computers web site. Retrieved March 31, 2011.
    http://history-computer.com/Internet/Birth/Baran.html

[36] THE CALIFORNIAN IDEOLOGY. Richard Barbrook and Andy Cameron (August 1995).
    http://www.alamut.com/subj/ideologies/pessimism/califIdeo_I.html

[37] 1642-1652: The Diggers and the Levellers. A history of the radical movements the Diggers
    and the Levellers which sprung up around the English Civil War. Jim Fox
    From Revolutions Per Minute. http://libcom.org/history/articles/diggers-levellers-1642-
    52/

[38] Francesca da Rimini. Socialised Technologies, Cultural Activism, and the Production of
    Agency. Doctor of Philosophy in Humanities and Social Sciences 2010. P 200.

[39] Remediating the Social. DIWO: Doing It With Others. Marc Garrett and Ruth Catlow. P 69.
    Published by Electronic Literature as a Model for Creativity and Innovation in Practice.
    University of Bergen, Department of Linguistic, Literary and Aesthetic Studies PO Box
    7805, 5020 Bergen, Norway. Editor: Simon Biggs. University of Edinburgh. 2012.

[40] "Online creation communities for the building of digital commons: Participation as an eco-system?" Contribution to the panel on "Organizational principles and political implications" of the International forum on free culture – Barcelona October 30 2009. Online creation communities for the building of digital commons: Participation as an eco-system? Fuster Morell, Mayo (2009) Pdf. P12. http://www.onlinecreation.info/?page_id=27

Data Sonification; An Emerging Opportunity for Graduate Music/Sound Design Departments to Expand Research in an Art and Science Collaboration

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Abstract: As the size of data sets grow larger and larger, they are becoming more difficult to investigate for unique patterns and anomalies. Most tools for this sort of investigation are visually based. There is an opportunity with additional tool of sonification to enhance the ability of researchers to observe new relationships in data sets. A synthesis of sight and sound increases the likelihood of exposure of new features and interconnections hidden in more standard "visual only" modes of investigation. The creative application of musical understanding of acoustics, physical modeling synthesis, harmony, even musical style enable the use of sonification to become part of the curriculum for graduate level study not only in research labs but in music conservatories and schools world wide. The bridge between musical practice and sonification is just beginning to be realized, but the potential reward is great. This white paper proposes to layout some basic premises that music and sound art departments should consider when introducing the concept of sonification tool set for scientific discovery. The aim is to encourage new resources that will leverage the rich history related to music and sound design to create new tools and paradigms for the expanded investigation of ever growing and varied data sets across a wide range of disciplines.

A common definition from 1994 of sonification is, "Sonification, a form of auditory display, is the use of non-speech audio to convey information or perceptualize data."[1]
This is the reference that is commonly used because the word itself has not made it into the Oxford English Dictionary, Larousse, Zingarelli or any number of dictionaries worldwide. This is a testament to how new this field is. While graphs and charts have been with us since Gutenberg and before, it is not until ready access to databases and the conversion of numbers into sound via computers that conception of sonification was even realistic as a practice. To create a sonification one needs to formulate a computer program to take a sequence of numbers and makes a scaled and converted output of those numbers as some sort of sound. This sound could be musical notes where the pitch of each note represents a value, for example. In truth there is no standard yet for this conversion, it could be any combination of all sorts of transformations of correlated sets of numbers into a set of sounds and the acoustic parameters related to those sounds.

The very fact that there are no standards and little use case studies opens this field of research into an interesting range of new investigation. To even begin to formulate a sonification "scheme' of one sort or another requires a convergence of many disciplines. Ideally, there should

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1 Kramer, Gregory, ed. (1994). Auditory Display: Sonification, Audification, and Auditory Interfaces. Santa Fe Institute Studies in the Sciences of Complexity. Proceedings Volume XVIII. Reading, MA: Addison-Wesley. ISBN 0-201-62603-9.

be individuals involved that are expert computer programmers, acousticians, psycho-acousticians, composers and sound engineers and that would not include the individuals needed to design use case studies and testing regimen. Such an eclectic combination of skill sets points up the challenge and the promise of this area of research. It truly is a fully STEAM (science technology engineering ART mathematics) and the interesting part of this concept is that while the scientific techniques for doing the conversions of data into sound are easily conceivable, what isn't as clear is the artistic or at least "crafting" of sonifications that have the ability to stand the test of sustained listening. Far too many examples of direct conversions or oversimplified re-mappings of data into repetitive, grating or even unlistenable examples are found by anyone doing a general survey of the various efforts worldwide to create sonifications. One can think of a visual equivalent of a badly rendered graph or pie chart with bad color choices, too small, no differentiation between the data being contrasted etc. Many aesthetic challenges shape the choices made by the composer/sound designer working with the final realization of the conversion of a data flow to sound.
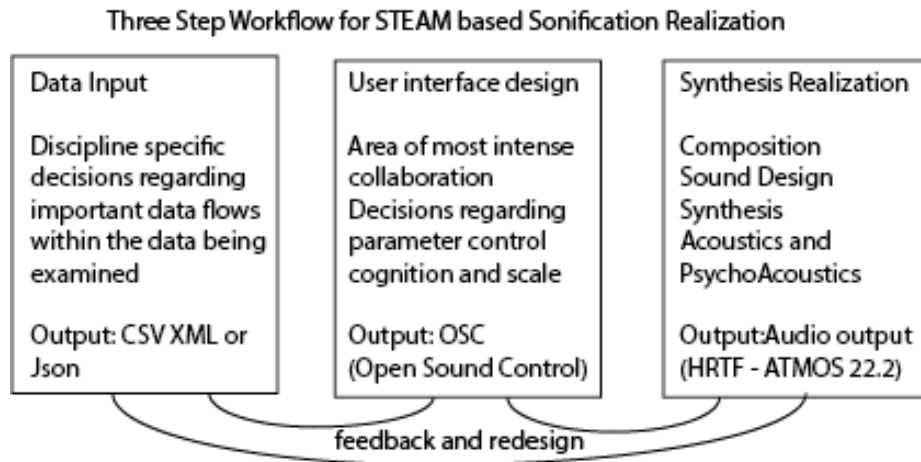
Most of the challenges of the area of electroacoustic music, which is the general set of techniques used to make sonification in most cases, are also in a transitory and unsettled place. The famous aesthetic theorist and philosopher Theodor Ardono was the first to articulate the problem and promise of electronic music production. "Infatuation with the material along with blindness toward what is made out of it resulting from the fiction that the material speaks for itself, from an effectively primitive symbolism. To be sure, the material does speak but only in those constellations in which the artwork positions it".[2] In this case, Adorno is concerned with the fascination of early electronic music composers with the "Material" or the new sounds themselves and not the context or form in which these sounds will be placed.

The same problem persists across into the area of sonification. Too often the representation of the data set is explained in a text that precedes the act of listening to the actual example of sonification being played. The skill and craft, one would hope even the art of sonification in a future context will transcend this boundary of explanation and create a type of realization that is self realized, self explanatory. The form or framework of the sonification itself must therefore be informed of all the various disciplines outlined before, otherwise the content of the sound is totally amorphous and without internal structure. The act of creating a fully realized sonification requires that all the aspects of science, technology and art related to the specific data set being sonified, require tight collaboration and cross communication to be fully actualized,

This sort of fully realized sonification can not be successfully managed without a well defined and rigorously followed workflow that allows each of the participants across all the disciplines the option to bring their particular understanding and contribution to the overall process. To be clear this is a new regimen that is just being formulated after years of research in the area and many heuristically based approaches to creating a context to accomplish the goal of a standardized system for functional but listenable sets of sonifications across a broad range of disciplines and potential collaborations.

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2 Adorno, Theodor W. (1955), "The aging of the new music." In: Theodor W. Adorno, Essays on music [selected by Richard Leppert; new translations by Susan H. Gillespie]. Berkeley, Los Angeles: University of California Press, 2002: 181-202.

Below is illustrated the basic workflow diagram for three interdependent activity requirements to fully realize a sonification in a way that takes into account the needs of the specific discipline being examined, but allows each of the varied sets of skills required to do this optimally an area of focus within the process itself that will create the most efficient interactivity between the skill sets. By clearly defining the expectations for each of the collaborators the likelihood of meeting the full potential of the realization are maximized.

Three Step Workflow for STEAM based Sonification Realization

Data Input	User interface design	Synthesis Realization
Discipline specific decisions regarding important data flows within the data being examined	Area of most intense collaboration Decisions regarding parameter control cognition and scale	Composition Sound Design Synthesis Acoustics and PsychoAcoustics
Output: CSV XML or Json	Output: OSC (Open Sound Control)	Output:Audio output (HRTF - ATMOS 22.2)

feedback and redesign

Phase One

The specific discipline puts forward a set of data or enables access to a specific real time data flow that the researcher wants to examine. This will require an interview process from the sonification team to more fully understand the needs of the researcher and the very specific areas of understanding that is being investigated. For example: A Geoscientist has a volumetric data set representing a transitional area of geological significance. This can be rendered in 2-d slices or to a 3-d goggle set visually, but sonically the area can be represented as a sound mass where specific sounds represent specific rock types localized in 3-d acoustic space. The Geoscientist in this case would be tasked with supplying access to the volumetric data that represents the geographical layers in general with the coordinates in three dimensions relative for the specific site in question. This information in many cases can be provided via Excel sheets as CSV (comma separated value) tables. In other cases, with real time data streams, for example, specific information can take the form of dynamic XML or Json data flows over the Internet in the form of UDP or TCP/IP packets. All these sorts of technical details need to be communicated and coordinated and access to the information must be provided. This requires the assistance of Computer Science expertise as well.

Phase One includes these specific collaborators
  1. Researcher in Specific Science under examination (GeoScience in the example above)
  2. Project Sonifier (Composer-Sound Designer)
  3. Computer Science specialist (data transfer and message protocol formatting)

Phase Two

The project coordinator or sonifier must create a user interface that will allow the Researcher to manipulate and interact with the data once it is represented as a sound stream. This requires breaking the sound environment into one of two possible domains. Time based or sequential, where the information comes as a time series data flow and the changes in sound reflect the dynamic shift in the information over scaled time or the data set is represented as a static object that can be examined, manipulated and navigated upon. IN collaboration the Researcher and the Sonifier must agree on which of these two or both representations the researcher would want. Then there needs to be a clarification regarding scale, range and in some cases preferred musical or timbral style. Once the options have been clarified the sonifier then coordinates with a designer of engineer to create the user interface. This can take the form of an actual specialized hardware interface that is designed for the specific project or a web based browser set of buttons , knobs and value readouts that communicate to the researcher the current state of the "sonification engine" At this point the specific out put of the system must be codified into specific acoustic/musical parameters (location, frequency, amplitude, timbre etc.) and those parameters need to be parsed with in the OSC (Open Sound Control)[3] protocol for direct communication with the Phase Three synthesis functionality.

Phase Two includes these specific collaborators
  1. Project Sonifier (Composer-Sound Designer)
  2. Researcher in Specific Science under examination (GeoScience in the example above)
  3. Design Engineer (either hardware or software CHI expert)

Phase Three

Once the OSC parameters have been set this has the distinct advantage of being fairly self-documenting. A typical OSC message may look something like this: /freq 440.032. This is pretty clearly requesting an oscillator to sound at a frequency of 440.032 HZ. Locational information would be express in terms of Cartesian coordinates /x /y /z … /amp for amplitude or what ever was decided on in the design of Phase Two. The real craft and subtlety of this portion of the design work is to take these data flows and working in interaction with the recently codified User Interface, create a palatable if not masterful new acoustic environment that is directly reflecting the data that is under investigation. It is at this point that the real opportunity to fully engage graduate level student sound designers/composers to create and push forward this new discipline. The opportunity expands as an area where Psycho-Acousticians and well as Acousticians can become involved in refining and redefining the sound output formats and interface interactions to make a specific and functional, quite possibly reusable new resource for each of the participating scientific disciplines. At this point user testing will yield results regarding the efficacy of the specific sound design approach.

Phase Three includes these specific collaborators
  1. Project Sonifier (Composer-Sound Designer)
  2. Acousticians

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3 Wright, M., Freed, A., "Open Sound Control: A New Protocol for Communicating with Sound Synthesizers", International Computer Music Conference, Thessaloniki, Greece, 1997.

3. Psycho-Acousticians (Music cognition specialist)
4. Human Interface Design Evaluators

The bottom of the diagram shows arrows of "feedback and redesign" which will obviously be part of the development process for each of these lines of tool creation. Keep in mind at the end of the design/redesign process an entirely functional and potentially widely reusable new tool for each specific discipline that goes through this process will be being realized. Wholly new ways of investigating scientific data sets will emerge and the potential synergy of this line of investigation in conjunction with the already well establish visual modes of research is very promising.

As technological innovation is reframing our consideration of the tasks before us, here is yet another opportunity to reframe an aspect of graduate studies in music and sound design. By implementing this sort of regimen within the context of the curriculum design for graduate study in those fields, this new tool of sonification can become an integrated part of a dynamic new way of understanding the place of sound in our new media culture and foster collaboration across all the various disciplines outlined above. It must be remembered that the tools to even think of this course of study have just become widely available in the last decade or less, so it is understandable that there has not been more defining research in this area.

For a true and usable new version of sonification to emerge it will take the sort of cross disciplinary collaboration that has been outlined here. Each participant must understand her or his specific discipline and problem well enough to articulate the design specification that is required. This is what makes this approach a promising tool for fostering collaboration in Science Technology Engineering ART and Mathematics. It is across these disciplines that students will discover the new resources and potential of the act of collaborating as well as being part of creating a whole new class of tools that may help researchers in all those areas of study to push the limits of research and understanding.

Environmental Equity: Enabling Excellence in Media Art and Science in Under-Served Communities

http://wp.me/P2oVig-ke

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A. Abstract

Environmental quality, good design, and regard for health information bear much relevance for communities experiencing long term toxic damage and the associated health risks. Recent developments in data visualization, environmentalism, and sustainable arts show citizens' art, citizens' science and community-based innovation in these fields at the center of knowledge production. 'DIY' research, which is both flexible and responsive to community issues and concerns; which uses open platforms and complex collaborations between experts, citizen scientists, artists, and others, is successfully bridging cultural gaps and inequities in the fabric of public learning.

By examining contemporary models, this paper takes under consideration, how media literacy and community media-making, in the context of environmental arts and sciences, might enable underserved communities. Media literacy, community-based media and creative collaborations with scientists and artists are effective platforms from which civic engagement, participation, and direct production of community history are made. Both art and science link citizens' to the value of diverse and very personal sets of data. When coupled with digital literacy and digital media arts skills, the activities of art and science are duly empowered, have greater "reach" and learning benefits.

The research is sourced from new approaches to the arts and sciences where new media is concerned represented in various contemporary projects. (see Sections 1.2, and C) On the one hand, there are new fields of inquiry gathering around "dynamic information" (sentient, environmental, visual). But, this information does little good unless its "innovation" is shared and shaped equitable. The primacy of
"media literacy" as a fundamental component for human emotional health, education and welfare is thus another impetus. Thus,apparent cultural inequities in digital means are touched upon. The primary focus articulates a crucial gap between information and knowledge experienced by so many as a disconnection from vital services, representation, and resources. Under-served communities suffer with respect to these lacks in the arenas of environmental science, communications art, public information and health information. The paper argues that it is essential to balance these inequity; to lift the underserved out of computer "job training" trajectories, and to offer better, more unique, more challenging opportunities for creative thought and community-based learning. For these communities to engage with broader social, political and cultural dialogues where environmental issues are concerned, the "digital divides" holding them back; the digital literacy necessary to perform and the creative collaboration with artists and scientists must be supported.

B. Introduction and Context

A growing concern for many American citizens are environmental issues such as climate change and sea rise which threaten the very sustainability of our planet. The now established "green" movement has manifested in numerous high-quality sustainability strategies for cities and towns under the influence of major organizations such as the US Green Building Council and LEED

certification programs in architecture to significant waste management analysis programs for major newspaper manufacturers, to garbage collection agencies and electronics recycling businesses. These are frequently described in local and national press. Across this proactive endeavor, however, basic concerns with equity in environmental protections and public information also arise. It is a simple fact, for instance, across a rural and urban America impacted by Big Agriculture and mining industries, that poor, ethnic minority communities are those most likely to be affected by environmental decline. These communities are also least likely to possess empowered resources for substantive education in or development of political action around environmental art and science. These communities generally also lack engagement with both digital media literacy and information arts.

At the same time, community concerns surrounding the effects of policy, environmental decision making, and proximity to industry upon health and long term quality of resources such as land and water are high. A recent survey conducted by the Public Policy Institute of California on "Californians and the Environment", showed growing concern towards the impact of global warming among ethnic minorities. (Alonso, 2012) The New America Media organization, responding to the fact that "there was a lack of environmental coverage in the ethnic media outlets" gathered together a panel and group of reporters to respond to concerns brought about by introduction of the survey results at the World Affairs Council in San Francisco. (Ibid, 2012a) Panelists agreed that "Latinos, Blacks and Asians" were "often left out of public discourse on environmental issues" in California, at the same time acknowledging the strong role that people of color play as environmentalists across the state. (Ibid, 2012b) Survey results supported this idea through indication that African Americans and Latinos linked action on behalf of climate change with job growth, when asked to respond in telephone interviews. (Ibid, 2012c)

Roger Kim from the Asian Pacific Environmental Network contextualized findings from the survey in remarks about the explosive fire in the Chevron refinery in Richmond, and the asthma and cancer rates that go unexplained for workers and neighboring residents "particularly those in the plant's immediate vicinity—comprised mostly of poor black and Hispanic residents—still urged to "shelter in place." (Burness, 2012; Miller, 2012) Kim linked these facts to the strong sentiments that communities of color have about environmental pollution. Neighborhoods such Bayview Hunters Point and Treasure Island are frequently in the news where excessively high breast cancer rates, radiation, and regular subjection to other post-industrial toxins are concerned. These communities house disproportionate numbers of African Americans, and homeless people. Data on drinking water quality in such neighborhoods and regions, suggests increased likelihood of health damage to minority populations. (Gross, 2012) Meanwhile, community statistics on environmentally disastrous lead levels from Interstate 5, constructed to avoid
higher priced real estate areas, but affecting largely Latino farming communities such as Kettleman's City, are horrific. (Weinstein, 2010; Mother Jones, 2010; Balkin et al 2005, Scott 2010)

During the subsequent panel discussion, consensus was reached that environmental impact is felt most strongly in minority and low income communities, while at the same time there persists a profound "disconnect between emerging policies and the members of these communities" (Alonso, 2012d) For these reasons, it must be a central concern to ensure that American communities of all kinds have access to and knowledge of meaningful information. Moreover,

that they are in a position to use information and data to promote community literacy; record, and sustain public response. Under-served communities will be better enabled to join environmental discourse and debates around sustainability in terms of their own needs if they have access to and understanding of that information, are capable of producing their own information and are enabled to foster greater knowledge-making skills on environmental issues through media literacy, artm and science.

1.1 Effective Programs: Bridging Crucial Gaps in Environmental Information and Literacy

Despite advances in networked technologies, wireless infrastructure and mobile communications, even progressive urban areas, show a severe lack in computer literacy and networked technologies for lower income, elderly, immigrant, ethnic minority communities. (Berman, 2007). These "digital" and educational "divides" between whiter, wealthier, more educated communities and older, lower income ethnic minorities reinforce information and literacy inequality when it comes to access and engagement with public information. (More and more of which is going on line)

How can excellent initiatives in education, media literacy and new technologies for underserved communities not only be created but be sustained? In today's highly mediate reality, media literacy is essential to participation in the "digital public." Computer and information is an essential component of a reasonably high degree of participation in education, government, and social well-being. From this perspective, several components of "excellence" must be achieved to satisfy the aforementioned concerns among leaders of ethnic communities about environmental information and are summarized below.

Research Observations Summary

Minority and low income neighborhoods need greater support for education in and development of sustainable media arts programs directed at computer literacy, digital media literacy, and ongoing community-based media arts and sciences. These communities also need creative support for community-based health, environmental arts and science education in which community-concerns are central and actions can be addressed to improve upon existing conditions and link these communities more directly to environmental leadership, sustainability and health initiatives.

1.2 Recent Program Directions (see projects mentioned at end)

a. The greening of school campuses which brings soil science, composting, energy efficiency, and rainwater catchment to young people through art and design around sustainable gardening and community supported agriculture presents rewarding collaborator opportunities for artists, scientists, teachers and students. Curriculum designed to foster creative thinking around art and science and impact state curriculum in the understanding of gardens and process for garden teaching should be implemented. It is also possible to extend this comforting and familiar environmental artform – the garden – to senior and disabled populations,

communities of color who would benefit from low-cost organic food and flowers; and the mentally ill. (see http://www.freefarmstand.org/about/)

b. Citizen scientists using wireless technologies, interpreting and visualizing their own data, along with environmental science and urban sciences in K-12, adult leadership groups, community arts spaces and health organizations create meaningful skill-sets and curriculum and public information applications for communities. Grassrootsmapping.org initially monitored the BP Oil Spill in the Gulf of Mexico for the air using weather balloons and wireless cameras. Citizen scientists also documented much of Katrina's aftermath. The project now provides balloon-based mapping "kits" and public information on how to map, as well as workshops in mapping to the public. Open science platforms encourage creative hacking and community-made documentation on local environmental issues. (See PLOTS)

c. Bilingual, English and Spanish programs for youth through Presidio Parks and Services, Crissy Fields Nature Center and San Francisco Recreation and Parks provide rich resources for communities of color to engage with nature and share urban parklands. Latina environmentalist Maria Jose Alcantra, who grew up in San Francisco's Mission District, a low income ethnic community, says that programs through the Crissy Fields nature center starting at fourteen, "changed her life." She now works to "bridge the gap between the Latinos and the environment" showing "the newcomers and youth from under-served communities" that they do not have to live the stereotype of being out of the environmental "loop." (Alonso, 2012e)

d. Green school buildings designed to produce interest in building functions and systems throughout the day teach young people and adults how close at hand environmental efficiency and impact actually is. Users of these schools, including student and adult populations, can measure and collect data on their own daily energy and water efficiency using systems tools designed into the buildings as accessible tools. The US Green Building Council and LEED organization have partnered to promote this type of initiative nationwide. Note: Critically speaking the majority of these "green" schools are not yet located in under-served communities. However, their value as a model cannot be underestimated.

e. Curriculum strategies linking arts and science projects directly into neighborhoods via digital media, such that participants become engaged in researching and making information about their locales, or studying environmental issues, and where environmental design is learned through the community space from and by the community at large are particularly effective. (see The Living Library)

1.3 Roadblocks and Inhibitors as the Basis for Suggested Actions in the Arts and Sciences

a. Interdisciplinary collaboration which does not remove communities from art and science, but which places them in direct contact with critical processes and disciplines, i.e. experimentation, trial and error, documentation, formulation of questions, execution of ideas is fertile ground for ongoing excellence in community-based, citizen-lead arts and sciences and the deployment of science into public, educational streams, i.e. art spaces, special projects, consultations, and curriculum. However, it is not without significant stumbling blocks. Public funding for collaborative arts and arts education is meager, if not non-existent,

in the United States and science education is frequently geared toward the expedient fulfillment of state curriculum standards and proficiency testing, rather than creative exploration of ideas or immersion in relevant and meaningful practice. Educators, in fact, have only so much time to elaborate on curriculum while still being effective in meeting state requirements. Standardized testing routinely fails to include the positive effects of learning outcomes generated without quantifiable "results" and tends to harness student power in the form of wrote learning and multiple choice.

Suggested action: It is suggested that funding bodies, governing research foundations, and art institutions such as the NEA, National Academy of Sciences, and the National Research Foundation work together with federal technology programs and organizations such as Zero/Divide or the Broadband Technologies Opportunities Program (FCC) as well as with individual artists, scientists and researchers (from within developed collaborative proposals) towards robust funding initiatives for a multitude of collaborative projects wherein the permanent installation of digital communications technologies and their ongoing support and implementation in the arts and sciences, through software development and research, is a significant criteria for the expression of the artwork, development of scientific study, and ongoing media literacy.

b. Race, class, gender and cultural factors which persist in socially stratifying quality educational initiatives in the arts and sciences, including their funding and the effective "reach" of relevant ideas and empowerment into public education, reinforce divisions in participation, comprehension, and skills. What is critical for the implementation of artistic endeavor from which to "learn science" and science projects with which to "do art" is first the addressing of fundamental social and cultural inequalities in ongoing access to resources and related knowledge as the basis of any design/art/science/or engineering initiative.

Suggested action: It is suggested that national funding bodies, federal technology agencies, state public art granting foundations, research institutes, and international organizations such as UNESCO, because impediments to career paths start young, race, class, and gender imbalances in engineering and science have been widely acknowledged, and lowered participation and performance expectations, particularly in the sciences, among poor and ethnic minority communities abound, devise funding initiatives to stimulate solutions to social and cultural inequalities, particularly "digital divides" in media literacy and media arts "gaps". In this context, projects in support of gender equality or which close an "age-gap" should also be supported.

c. Environmental data means a great deal to those most affected by it. The central concern is how to ensure meaningful and impactful community engagement with information and sustained ability to use it.

Suggested action: It is recommended that specific support for action-based and curriculum-centered public projects targeting economically disadvantaged and ethnic minority communities be funded. Projects in which maps, data visualization, locative and sentient media, critical media literacy and other higher level developments in software and new technologies are deployed will assist in redressing inequalities in information and computer literacy. Stakeholders might be National Endowment for the Arts, Foundation for the Alliance of Community Media, Centers

and Institutes for Digital Literacy, and the National Foundation for Educational Research, and National Research Foundation.

C. Quick Summary of Strategies

a. Foundation support at the federal level for localized urban programs which foster the growth of critical media literacy, i.e. access to technologies and curriculum and which support its creative use among under-served communities is suggested.

b. Grants for public education initiatives from major arts and science funding bodies to seed the development of hacker spaces, grassroots technology labs and community-based media arts projects in collaboration with community organizations, lower-performing schools, and local institutions in neighborhoods and districts most affected are suggested.

c. Additional ongoing funding and infrastructural support, pro-rated over several years to install new technologies, computer labs, provide technical support, equipment monitoring, and substantial development of media arts projects geared at "hands on" learning and creative, critical awareness and use of media, i.e. development in critical media literacy as opposed to "job skills" training are suggested.

d. Development of specific funding support for projects in the arts and sciences targeting under-served communities which utilize the creative ideas of individual artists and scientists for localized collaborations with communities, and from which can be developed community-based research, community history/health production, and community exchange around media representation, media literacy, and media arts in conjunction with environment concerns and their impact upon community resources and community health initiatives are suggested. (See "Tobacco Free"--http://www.tobaccofree.org/ - Invisible 5)

D. Conclusions

Questions posed from this brief paper are:

1) How can projects for under-served communities' sustained involvement with environmental arts and science, such that these communities are capable of effective critical engagement with issues of cultural and political relevance to themselves, and, in terms of social and cultural equity, across digital divides and arts and science cultures, be designed?

2) How can higher-tiered arts and science foundational support be developed to ensure that excellence in experimentation, scientific inquiry and method, trial and error, expertise, and literacy in the arts and sciences be directed and supported in communities currently underserved?

Notes/Resources

Alonso, Gabriele (2012a-e) "Survey Among Minorities Discloses Concern for the Environment" in El Tecolote, Vol. 42, No. 16. Agosto 16-29, p. 6.

archKIDecture || architecture for kids || home. http://www.archkidecture.org/

Barr, S. (2011) Green Schools That Teach: Identifying Attributes of Whole-School Sustainability, Department of Design and Advertising, Colorado State University.

Berman, T. (2007) Digital Inclusion in San Francisco. Goldman School of Public Policy. http://www.sfgov3.org/ftp/uploadedfiles/digital_inclusion/reports_publications/UCBDigitalInclusionReport060282007Final.pdf

Black, G. (2005). The Engaging Museum: Developing Museums for Visitor Involvement. New York, NY: Routledge.

Burness, C. (2012). "Fire at Chevron Refinery, Many Go to Hospitals". El Cerrito Patch. http://elcerrito.patch.com/articles/explosion-fire-reported-at-chevron-refinery

California Department of Education. (2012) Teaching Shortage. http://www.cde.ca.gov/pd/bt/ts/

Dirkson, J. (2012) Designing for How People Learn. Berkeley: New Riders.

Free Urban Farm Stand. www.freeurbanfarmstand.org/about

Grassrootsmapping.org www.grassrootsmapping.org

Gross, L. (2011) "Pollution, Poverty, People of Color: No Beba la Agua. Don't Drink the Water" in Environmental Health News, Environmental Health Sciences. www.environmentalhealthnews.org

Invisible 5 http://soex.org/exhibit/12.html http://www.academia.edu/2318113/Field_Effects_Invisible-5s_Illumination_of_Peripheral_Geographies

Junior Center of Art and Science http://www.juniorcenter.org/

Living Library - SEAD paper http://www.alivinglibrary.org/treeentrance.html

Marin Country Day School | EHDD http://www.ehdd.com/work/marin-country-day-school/

Miller, J. (2012) "Smoke City", Earth Island Journal: News of the World Environment. September 10, 2010. http://www.earthisland.org/journal/index.php/elist/eListRead/smoke_city/

Mother Jones (2010) "What's Killing the Babies of Kettleman City?" http://www.motherjones.com/environment/2010/07/kettleman-city-toxic-birth-defect-cluster

The National Environmental Education and Training Foundation, (2000)."Environment-based education: Creating high performance schools and students." Washington, DC.

Prairie Crossing Charter School. (2011). Outdoor Classroom. Retrieved from: http://www.prairiecrossingcharterschool.org/outdoor

Public Lab – A DIY Environmental Science Community http://publiclab.org

Scott, E. (2010) Field Effects: Invisible-5's Illumination of Peripheral Geographies, art journal. http://www.academia.edu/2318113/Field_Effects_Invisible-5s_Illumination_of_Peripheral_Geographies

Tobacco Free – Youth Media campaign http://www.tobaccofree.org/

Weinstein, A. (2010). "Kettleman City's Toxic Web". Mother Jones: http://www.motherjones.com/environment/2010/07/kettleman-city-toxic

Welcome | San Francisco Green Schoolyard Alliance http://sfgreenschools.org/

Zerodivide www.zerodivide.org

Emergence of New Institutions for Art-Science Collaboration in France and Comparison of Their Features with Those of a Longer Established One

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Introduction and Disclaimer

The situation of art-science research and collaboration in France is very diverse and non-standard, when compared with scientific research. An interesting feature of this diversity is that many avenues are explored to promote, foster, and support art-science. Depending on the nature of the works, some places might be more suitable than others to the development of a specific project. The drawback of atypicality, particularly in an effort of description, is that it is very difficult to find rules, common grounds, or shared objectives between all these places.

In order to give a better idea of the field, I have invited four recent institutions in art-science collaborations: EnsadLab (a research laboratory at the École nationale supérieure des Arts Décoratifs - EnsAD, a public university of art and design and one of the most prestigious French "grande école"), l'Atelier Arts-sciences (a collaboration between the Hexagone Scène Nationale and Minatech, the CEA (Commissariat à l'énergie atomique et aux énergies alternatives) research center operating in nano-technologies), IMERA (a center for cross-disciplinary collaborations hosting art-science residencies) and VIDA (a research theme on art-science collaborations inside a Computer Science research laboratory) together with the now well-established and internationally acclaimed IRCAM research laboratory (on all the techniques around music, and even live performance such as dance or theater). This white paper will not give an overview of all the institutions, artists, scientists, and engineers working in this field (contrary to the Rapport Art, Science, Technologie coordinated by Jean-Claude Risset in 1998 which was intended to be more exhaustive). [1]

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1 http://media.education.gouv.fr/file/95/6/5956.pdf (last accessed 3/22/2013)

The purpose of this article is to draw some suggested actions about the current state and the future perspectives of art-science projects in France or in the US (since this article will be published in the SEAD White Papers 2013) based on a small set of representative institutions which have been chosen for their diversity. Industry is the big figure is missing of this choice; the reason is that, to my knowledge, corporate art-science collaborations are generally mediated through public institutions in France. Yet, the case of the Atelier Arts-sciences is an exception, since it is the construction of a balanced collaboration between Hexagone, a national theater, and CEA, a major French company on applications of energy.

I hope that the modest contributions of this white paper will benefit the entire art-science community. My purpose was not to give an exhaustive overview of French institutions in this domain. My aim was to raise some important issues in our domain and propose a first set of suggested actions for the future.

A Comparative Analysis of Four Art-Science Institutions

For the readers who are visual learners, I will begin with a figure on how the institutions can be represented with respect to their environment. Then I will go deeper into the description of the key figures: spectrum of activities in research, education, and art/science collaboration, size and distribution of the staff on these activities, prospects and projects. Last, I will conclude the article based on a comparison between a long-term institution (IRCAM) and the other emerging ones (EnsadLab, Hexagone/Atelier Arts-sciences, and VIDA).

Human Resources

As shown by Figure 1, VIDA is a transverse topic hosted by the HCI department and common to all the research groups in this department. L'Atelier Arts-sciences is a joint project between CEA (a major French industrial actor in nano and micro technologies) and l'Hexagone (a national theater). The three main activities (Residencies, Supervision, and Publications) are shared between the two mother institutions. IRCAM is hierarchically divided into four departments (R&D, Creation and Diffusion, Education and Cultural Outreach, Research/Creation Interfaces) that are, in turn, subdivided into Research Groups, Events and Productions, and Education and Training Programs at various levels (from theoretical to applied) and for various publics. IMERA is a University Foundation in Aix Marseille University; it is part of a network of four French Institutes for Advanced Study. Last EnsAD, besides an Education Program with a first foundational year, and 4 specialization years, has a research laboratory EnsadLab subdivided into Research Programs.

Size and Activities

The 5 institutions are very different in size and in activities. IRCAM is by far the largest center with 150 permanent collaborators and 40 visitors for the research part and numerous artists in residencies for artistic creations. VIDA differs from the other 2
emerging institutions by the fact that it is the only one without permanent staff specifically dedicated to art-science activity. Each of the 23 members of VIDA is also part of a scientific

research group and devotes from 10 to 50% of her/his activity to art-science. EnsadLab has 6 part-time personals: a director, and 5 experts or associate professors. In addition, a large network of collaborators ensures that other competences can be brought to the students of the Lab. Last l'Atelier Arts-sciences, has 6 full-time personals and 10 part-times for an equivalent of 3 full-times. Among these part-time employees are scientists from the Universities or from CEA who use part of their time to collaborate on art-science projects. IMERA has a staff of 4; a scientific activities committee is responsible for the programming; the core activity is the hosting of scientists and artists in residence for periods from 5 to 9 months, as well as mixed teams of artists and scientists for shorter periods. IMERA hosts a large number of workshops around the research activities of the residents.
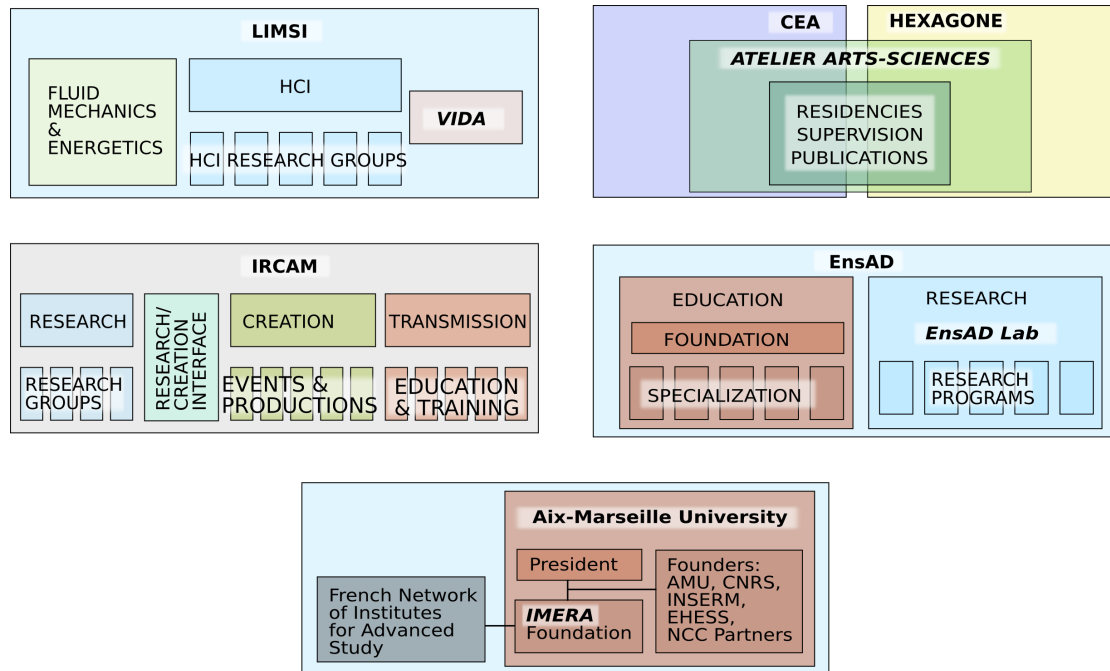

Fig. 1. Schematic Representation of the Institutional Structures

As for activities, IRCAM and EnsAD both have a Research and an Education department. IRCAM also has a Creation department because artistic and scientific research are intentionally separated, so that artists are not burdened with technoscientific issues and can focus on their creative process. Conversely, the status of researchers at EnsAD is more hybrid. The lab hosts artist/scientists who can operate both at the technoscientific and artistic levels. VIDA is dedicated to scientific research on art-science projects, but has not for purpose the creation of artworks. It is however considered as an added-value if artists, through their scientific collaboration, can produce and exhibit or perform singular artworks. L'Atelier Arts-sciences is mainly on the artistic creation side, for which science is considered as a resource. The future creative writing program will keep the same orientation to ground original art-science work on artist residencies with a strong scientific collaboration and supervision.

History and Perspectives

While IRCAM was created from the beginning as a politically-supported project for an institution operating in a cross-cultural domain intermediate between art and science, the other 3 institutions were built upon existing structure(s) as an extension of their scope. At its beginning, IRCAM was only supported by the Ministry of Culture and has evolved over the years to build and consolidate a strong research activity supported jointly by Ministry of Culture and Ministry of Higher Education and Research. This long process has made IRCAM a hybrid cultural/scientific institution that now combines recognized academic research activities, hosts a wider variety of artistic cultures, and offers a unique graduate program since 1993. But its birth was very different from the emergence of the other institutions that I would qualify as opportunistic constructions based on favorable configurations and environments.

VIDA was born from the conjunction of research activities at LIMSI both in musical sound analysis and synthesis, and in computer graphics for artistic applications, with the desire to better highlight the art-science projects so that they would be recognized officially as part of the LIMSI's activity. Since VIDA was not defined as a top-down political project, its consolidation took many years. In the case of a "standard" scientific laboratory such as LIMSI, art-science activities can be considered as suspicious for the evaluators. Personals who want to invest this field have to provide the hierarchy and evaluators with proofs of validity: publications, international connections, PhDs, grants...

The story of EnsadLab bears some similarities with VIDA, in that it was built on top of an autonomous institution as a kind of profitable "add-on". For EnsadLab, there was however a strong institutional pressure for hosting a research lab inside the school. Because of the harmonization of graduate and post-graduate studies in Europe, all the academic institutions were urged to offer Masters' and Doctorate programs including art schools. Since it is difficult to attract students without a research structures, art schools have promoted the creation of research lab such as EnsAD with EnsadLab with specific research orientations due to their primary artistic mission.

L'Atelier Arts-sciences, is an original story quite different from the other 3 institutions, since it is the result of the association between an industrial partner and a center for artistic production and diffusion. Even though it has developed several collaborations with academic partners since its creation, l'Atelier Arts-sciences was born outside the academic world. Its activity is also different from the other institutions because it mostly relies on a residency program fed by a prize. The residencies are offered to artists who can benefit of Hexagone for artistic development and production and from Minatec/CEA for scientific and industrial support. In addition to residencies, several events are organized along the year to present other (possibly formerly supported) art-science collaborations.

IMERA was founded in 2006 by historian Robert Ilbert and established as one of four French Institutes for Advanced Study; initial funding came from governmental stimulus funding, focused on the social sciences, which established an endowment for the four institutes; it was originally set up as a non-profit by the three universities in Marseille and the CNRS. Following the creation of Aix Marseille University, from the fusion of the three previous ones, in 2012

IMERA was integrated into the University as a University Foundation. The mission of IMERA is built around 'the human dimension of the sciences' and particularly to enable collaboration between the social sciences and humanities with the physical sciences, as well as between the arts and sciences. Residents receive work contracts or stipends.

Synthesis

As shown briefly through this description, art-science institutions in France vary a lot in their history, in their organization, in their productions. The diversity is certainly a sign of freedom and a source of wide production (the art-science field is broad and it is interesting to have institutions working in different areas) but it is also a sign of weakness (it is difficult to coordinate art-science activities between different institutions because their activities are not similar enough).

The suggested actions given in the second part of this article are intended to offer suggestions for sustaining the art-science domain without harming its diversity. In these suggested actions I can see several directions:

- legitimization of art-science collaborations: they produce skilled researchers who can benefit from creative capacities of the artistic world and understanding of the scientific and technical issues,
- valorization of art-science researches: they produce innovative results or products that can benefit the whole society by triggering new uses; they could not have been obtained from compartmentalized research works,
- attract new audience and new actors towards the art-science realm: if the offered environment is supportive enough talented artists and scientists (whether students or professionals) can be appealed by this domain and wish to make a career there; if the products of the research are matured and well supported they can attract a wide audience and possibly turn into a virtuous circle by orienting young talents towards art-science,
- for scientific laboratories, the presence of an art-science activity brings new opportunities for scientific research and development, it can also change the behavior of scientists and open them to social or human issues through artistic, architecture, or design-oriented projects.

Suggested Actions

EnsAD Suggested Actions arising from the experience of art-science research and education

1. Opportunity to develop: Cross-disciplinary encounters in an art-science doctoral program

a. Stakeholders: Universities, Art schools

b. Suggested actions: Promote encounters between students of different disciplines by registering them in a single art-science doctoral program that can accept both artist and scientist students. Organize events for hands-on/minds-on activities involving these two

types of students simultaneously. Promote interactions between supervisors in art and-science PhDs by encouraging shared supervision.

2. Obstacle: Difficulty in France to create a thesis in art and design based on the Anglo-Saxon model of "practice-based Doctorate"

Opportunity to develop: research and creation activities for cross-cultural PhD support

    a. Stakeholders: Universities, Art schools
    b. Suggested actions: Widen the scope of the scientific research to encompass issues such as social, gender, minority, disability, aging issues that can build a better common ground for such research than theoretical scientific issues. Define cross-cultural research program in which both artistic and scientific students can find interesting topics to develop. Teach art student scientific research methodology.

Hexagone Suggested Actions arising from the experience of Atelier Arts-Sciences

1. Opportunity to develop: Industrial, scientific, or artistic events around an art-science prize and residency program for diffusion purposes

    a. Stakeholders: Any institution hosting art-science residencies and research
    b. Suggested actions: Since art-science artistic and scientific productions are often non-standard and difficult to disseminate in their respective communities, it is valuable to develop events specifically dedicated to the diffusion of such works: art-science fairs, art-science festivals, art-science seminars and workshops...

2. Opportunity to develop: New public uses around art-science activities

    a. Stakeholders: Museums, Universities, Art Schools, Culture centers
    b. Suggested actions: Presenting art-science productions to a wide audience can offer a new vision of science to the public and improve the attractiveness of scientific curricula. Art-science productions can be employed to propose and develop new and unique uses by public of recent technoscientific advances.

3. Obstacle: Art-science development suffers from the compartmentalization of research, the separation between industrial and academic world, from the very selective mode of funding research.

    a. Stakeholders: Universities, Industries, Governmental funding agencies
    b. Suggested actions: Promote support for cross-disciplinary research, consider art as a valid companion for scientific research (for raising new issues, offering new domains of application, and as a user test-bed), develop ''creative'' industries such as entertainment and cultural industries, or stimulate industrial creativity through art-based management systems.

4. Opportunity to develop: Promote scientific education and practice to artists

a. Stakeholders: Scientific laboratories, Industrial laboratories, Universities, Art Schools, Culture centers, Culture Ministry
b. Suggested actions: Offer artists the temporary status of scientific researchers so that they can be immersed in a scientific environment and involved in research projects in collaboration with professional scientists.

IMERA Suggested Actions arising from the experience of the IMERA Art-Science Residency Program

1. Opportunity: New Innovative fields of research and creation are arising from boundary fields between many different fields of science with the arts not just information technology.

a. Stakeholders: Universities, Governments, Businesses
b. Suggested Action: There should be a deliberate plan of investment in art-science collaborations emphasizing the very diverse areas of science and engineering, not just computer science and information technology but also biology and life sciences, the physical sciences and social sciences.

2. Obstacle: There are many asymmetries in art science collaborations. Artists and Designers are Often Treated as Second Class Participants in Art-Science Collaborations.

a. Stakeholders: Art-Science Institutions, Participants in Art Science Collaborations
b. Suggested Action: Artists in art-science collaborations should be hosted and compensated in equivalent conditions to those that scientists have (for instance in sabbatical years, or in scientific collaborations).
c. Suggested Action: Art Science Institutions should seek to weaken asymmetries that interfere with productive collaboration. One mechanism is to have both scientists in residence and artists in residence in the same context and in similar propositions so neither are a small minority.

3. Obstacle: There are no established accepted criteria for evaluating Art-Science Collaborations.

a. Stakeholders: Funding Agencies, Artist and Scientists in ArtScience Collaborations
b. Suggested Action: There should be a concerted effort by all those involved in art science collaborations to develop rigorous ways of evaluating art science collaborations keeping in mind that different stakeholders may have differing criteria (eg the filing of patents and protection of IP is important to research engineers, while public audience numbers are important to performing artists).

IRCAM Suggested Actions arising from the experience of IRCAM scientific research and artistic production

1. Opportunity to develop: Good art-science research has two important features: the technoscientific developments do not conceal the artistic purpose, and the artist is not burdened by technological issues and can instead focus on his creation

   a. Stakeholders: Any institution producing artistic events supported by technoscientific research
   b. Suggested action: Since the technology should be at the service of the artistic purpose, it must be fully mastered and integrated, possibly up to its complete disappearing to the audience, with the potential difficulty of eliciting its role and justifying its cost.
   c. Suggested action: The environment offered at IRCAM for the creation of technological artworks is such that the artists can focus their energy on the development of strong artistic ideas because the technological issues are taken in charge by high potential technicians attached to their project.

2. Opportunity to develop: Attracting high skilled scientists and artists

   a. Stakeholders: Research and cultural institutions involved in Art-Science collaborations
   b. Suggested action: instead of looking for rare experts in both domains, organize working groups made of high-level artists and scientists in projects providing artists with the broadest possible exposure in the cultural scene and scientists in recognized research environments with strong expectations on scientific publications and transfer to the industry.

3. Opportunity to develop: Towards a better recognition of the role of artistic creation in society

   a. Stakeholders: Research program committees, Research funding agencies, Innovation agencies, Industrial fair organizers, Ministry of industry and commerce
   b. Suggested action: Since it is shown in many examples that early artistic experiments in digital media have often been a source of technological innovation usages that have later broadly developed in activity fields such as games, simulation and virtual reality, multimodal human-computer interfaces, multimedia search engines, etc., the role of artistic creation in society should be better and better recognized and supported in particular by academic institutions and research funding programs at national and international levels as an efficient factor of innovation.

VIDA Suggested Actions arising from the experience of artist/scientist collaborations

1. Obstacle: In academic careers, art-science collaborations are difficult to valorize (and also to disseminate in the scientific community). In artistic careers, scientific collaborations are not necessarily considered as positive

a. Stakeholders: Universities, Scientists in charge of evaluation, Funding Agencies, Art institutions, Art critiques
b. Suggested action in science: Take into consideration a wider variety of dissemination vectors than A-ranked journals or international peer-reviewed conferences: exhibitions in art galleries, art fairs, or museums, non-academic publications (public outreach, art books), live performances in well-renown festivals, etc. Promote art-science curricula for students or cross-disciplinary courses between Engineering Sciences and Humanities.
c. Suggested action in art: Take into consideration the capacity of artists to collaborate with scientists for a better promotion of their work, not through corporate funding or sponsoring, but through the presentation of the unique features of the collaboration together with the artwork.

2. Obstacle: it is very difficult to achieve a good art-science collaboration without an infrastructure that supports it

a. Stakeholders: Universities, Museums, Municipalities, Mediatheques...
b. Suggested action: Set-up program for art-science residencies by providing institutions with funding for artists and scientists. Arrange a place for hosting these residencies: a private housing for families and work places such as black boxes, workshops, or specific places inside a laboratory

3. Opportunity to develop: Scientific funding programs, Scientific journals, Scientific conferences, Research groups can accept art-science propositions even though it is not necessarily explicitly mentioned in their scope

a. Stakeholders: Program committees, Funding agencies, Academic staff
b. Suggested action: extend and consolidate the scope of calls (for papers, for projects, for special issues, for research projects...) towards explicit art-science propositions. Propose lists of possible topics in this area. Possibly facilitate the consolidation of such hybrid proposals by offering networking facilities to connect art and science communities.

APPENDIX

Appendix 1: The École nationale supérieure des Arts Décoratifs (EnsAD)

Emmanuel Mahé, Directeur de la Recherche de l'Ecole nationale supérieure des Arts Décoratifs

Jean-François Depelsenaire

The École nationale supérieure des Arts Décoratifs (EnsAD), founded in 1766, is a higher education establishment (Grande école) of art and design under the authority of the French Ministry for Culture and Communication. Offering a wealth of intellectual, creative and artistic

opportunities, its mottoes are innovation, multidisciplinarity and partnership. EnsAD has over 700 students, French and foreign, and offers courses in ten departments.

The five-year course, which includes a specialisation in one of the ten departments offered, complies with European harmonisation of degree courses (LMD) requirements. The EnsAD diploma is officially recognised as Master's level.

The School's research laboratory, EnsadLab, also offers ten or more research programs in the field of art and design.

École nationale supérieure des Arts Décoratifs is a member of the "Paris Sciences et Lettres - Quartier Latin" Research and Education Cluster (Pôle de Recherche et d'Enseignement, PRES).

In this context, École nationale supérieure des Arts Décoratifs operating in conjunction with Conservatoire national supérieur de musique et de danse de Paris, Conservatoire d'Art dramatique,

École nationale supérieure des Beaux-Arts and École normale supérieure, has implemented an innovative doctoral program SACRe (Sciences, Arts, Creation, Research), designed to unite the sciences and the arts and give creators and scientists the chance to invent together. The program consists of training exclusive to EnsAD and joint training with the other establishments involved in the SACRe program

http://www.ensad.fr

http://www.parissciencesetlettres.org

Key figures

720 students (15% foreign students);
A 5-year course;
10 departments: Interior Design, Art, Animation, Multimedia/ Graphic Design, Product Design, Textile and Texture Design, Fashion Design, Printed Images, Photography/Video, Stage Design.
1 research laboratory (EnsadLab);
18 technical studios;
2 amphitheatres, 1 exhibition gallery;
1 library containing 24,000 documents;
1 materials library containing 5,000 samples;
84 partnerships with overseas schools and universities;
50 partnerships with cultural institutions and companies;
3 partnerships with foundations;
25 public events.

The 10 departments

1. Interior Design: conceiving new spaces for living, at the crossroads between the plastic, symbolic and technical arts.

2. Spatial Art: training plastic artists to work with spaces in art, the spaces artists occupy.

3. Animation: developing mastery of expression through movement, with creativity and innovation as its goal.

4. Multimedia/Graphic Design: covering all design and production tools associated with both paper and multimedia.

5. Product Design: incorporating all the various contemporary design practices: industrial design, domestic and urban furniture, service design.

6. Textile and Texture Design: ranging from learning about the components of textiles and materials to their creative application, including the relevant technical, industrial and economic constraints.

7. Fashion Design: covering every form of production, from mass production to the bespoke piece, and include strategic foresight.

8. Printed Images: training image designers using drawing as their basis.

9. Photography/Video: teaching autonomy and professionalism in the execution and completion of photo and video projects in various registers, from artistic to documentary and communication.

10. Stage Design: a performance art that potentially calls upon all forms of expression to serve the dramatic tension created between a space and a narration.

EnsadLab, the School's research laboratory

EnsadLab provides the School with a specific entity engaged in reflection and research on programs relating to the fields of creation and innovation, whether already identified or emerging, linked to the social, economic, technological, political, industrial and cultural contexts of today's world. Combining research and training in research and through research, in preparation for a Doctorate level, EnsadLab currently consists of some seven research programs.

These programs are directed by research professors, faculty members and professionals with the highest levels of expertise.

Each program involves a number of research students (around five per program), French and foreign, selected by the school, all of whom hold at least a Master's degree – and some being

doctoral students – generally from EnsadLab partner research institutions (around 50 student researchers and 20 faculty members, researchers and well-known professionals).

EnsadLab has implemented an innovative doctoral program SACRe (Sciences, Arts, Creation, Research), designed to unite the sciences and the arts and give creators and scientists the chance to invent together. The program consists of training exclusive to EnsAD and joint training with the other establishments involved in the SACRe program.

Combining research and training « in research and through research », in preparation for a third cycle at Doctorate level, EnsadLab currently consists of some ten research programs covering the fields of both art and design, such as graphic design and typography, the design of services, objects or spaces, interactive installations, virtual spaces, new materials, mobility, etc.

For each of these programs, the school is developing public and private partnerships with universities (Paris 8, Paris 1, etc.), graduate engineering schools (École des Mines-ParisTech, l'École nationale supérieure, etc.), businesses (Tarkett, Orange, etc.) and research laboratories (CIE-Oulu University Finland, École Supérieure de Physique et de Chimie de la Ville de Paris - ESPCI ; Sciences Po Paris, SPEAP – Program on artistic and political experimentation ; Tokyo University of the Arts, Graduate School of Fim and New Media, etc.), museums (Pompidou Centre, Louvre, Muséum national d'Histoire naturelle – MNHN, etc.), considerably boosting its research potential. In one example, the partnership with Oulu, a Finnish national agency, combines the skills of the school's faculty and research students with those of the RealXtend IT team at Oulu Innovation Ltd. to produce an open source online virtual reality platform. The partnership also funds a research grant for a research student.

While EnsAD enjoys a prestige founded on its history as much as on its proven ability over time to encourage the emergence of numerous talents in all the different fields of design and creation, it is also widely reputed as a school with multidisciplinary credentials unique in France that has invariably associated "art and design", "arts and applied arts", allowing full scope to the very latest techniques and, nowadays, technologies. It is on these foundations that the school is able to position itself as a key player in research and innovation in the field of contemporary creative design. In order to envisage innovation in all its scope for impacting upon society, tomorrow's designers must be able to embrace the most burning issues of contemporary society at the same time as the most challenging technological questions. Between art and design, research at EnsadLab explores the most innovative technical dimensions in order to steer them according to concerns of form and substance as much as of function and use, taking into account their value as demonstration and/or utilization.

Each researcher, student or professor, must be able to occupy the field of research suggested by his or her own projects, but these projects must also contribute to the resolution of issues for the benefit of all; this is one of the crucial challenges in creating a dynamic that combines artistic creation and academic research. Capitalizing on all the experiments carried out within a single research program must serve to advance knowledge, methods, knowhow and techniques in a given field.

And these developments will find themselves represented and prized as much through creations, exhibitions and publications as through transfers to other fields such as industry.

PhD Program "Science Art Création Recherche" (SACRe)

The project "Science Art Création Recherche" (SACRe) aims at developing a new field of research by exploring the interfaces between the arts, and between art and science (hard sciences as well as human and social sciences).

It brings together, along with the ENS, the most important French schools of creative and performing arts in their respective fields: the École nationale supérieure des Arts décoratifs (Ensad), the École nationale supérieure des Beaux-Arts (Ensba), the Conservatoire national supérieur de Musique et de Danse de Paris (Cnsmdp) and the Conservatoire national supérieur d'Art dramatique (Cnsad).
The other partners of PSL, especially Collège de France, ENSCP, ESPCI and Université Paris-Dauphine, will also actively participate.

SACRe will implement a new kind of "Doctorate in Art" strongly articulating practice and theoretical thinking.

Its building-up will benefit from the experience of the Anglo-Saxon practice-based PhD, but differ from the much more theoretical model represented by the departments of arts, music and theatre at French universities.

Ten candidates are selected per year on the basis of the highest potential of creativity and of interdisciplinary working. They will get funded for 3 years. The balance between artistic fields – art, design, music, theatre – will be guaranteed as well as the presence of various scientific domains.
In a first phase, the selected doctorates will register both at the Graduate School of the ENS and at the school of creative or performing art principally related to their domain. In a second phase, a specific SACRe Doctoral School will be created within PSL.

The thesis, supervised by two professors (one scientist and one artist), will consist :

1. for the creative and performing artists, in a set of works or performances, accompanied by a document of varied forms (including texts, audiovisual and multimedia material) putting into reflexive perspective the artistic process ;

2. for the scientists, in a classical written thesis including some aspects of the process of creation or performance.

In both cases, these works will include at least an interdisciplinary project implicating other SACRe doctorates, artist and/or scientist.

A common training will also be organized for the PhD candidate, consisting in courses (about theory and history of arts) and seminars (based on student works), some of which will be delivered in English.
They will foster a shared identity and cross-discipline encounters. Each institution will contribute with dedicated means. The post-Master programs existing or emerging in the different art schools will closely articulate with SACRe, as some curricula will offer them the opportunity to participate to the courses and conferences of the program.

EnsadLab Research Program, a focus :

RESEARCH PROGRAM DiiP
(INTERACTIVE AND PERFORMATIVE DISPOSITIFS)

Experimenting and modeling 'dispositifs' for the creation of interactive installations and environments in art and design

The notion of 'dispositif' is increasingly important in contemporary creation, both art and design. [1] At the crossroads of artistic, technological and societal concerns, dispositifs by definition include an operative, effective or potential dimension. This is even more the case given that dispositifs are interactive, sometimes performative: they are formed by transforming the reality in which they occur and with which they engage. This EnsadLab research program aims to investigate the ways in which these creations can establish an operative relation with their context and, most of all, with their audience.

Participating at the highest level of technological development, beyond computer science and electronics, our projects encompass experiments with video, sound, text, light, robotics and materials. By creating environments, objects, programs and content, we invent and modelize specific and significant interfaces that allow for interactive and performative situations, which are pertinent to societal concerns, both current and future. With its articulation of aesthetic, practical (operative) and critical experience, our approach leads us to consider how multidisciplinary research projects, undertaken in partnership with research laboratories (public and private) in both social and hard sciences, can be put into the public domain (or 'published').

As of Fall semester 2013, this research program will be developed around five topics:

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[1] This French word is difficult to translate into English. Depending on the context it is usually translated as 'device' or 'apparatus', but neither one of these terms captures the specificity of the word. In the sphere of contemporary art, it designates the different and diverse elements – material, human and/or linguistic – that have operative capacities. In the social sciences, it is often used in the sense given by Michel Foucault (see the following English translation of the transcript of an interview with M. Foucault, http://foucaultblog.wordpress.com/2007/04/01/what-is-the-dispositif/).

1- Large Group Interaction
How to create interactive installations for a large group of people (up to several hundred), in the same place, and in such a way that they interact around a common dispositif?

2- Interactive light
Considering light as a new media, this theme experiments with and develops creations and interactive dispositifs in real time and in flux, using particularly responsive and versatile systems such as LEDS-based lighting.

3- Physical media
By connecting corporal physical activity with physical sciences, we seek to research and implement new responsive and controllable materials that allow for interactivity, bearing in mind their symbolic power and representative capacity (image, sound, light).

4- Situated interactive narratives
The notion of interactive narration, seen as a non-linear narrative or one with variable access points, frames the research and practical development of new ways – both artistic and experimental - of using mobile devices, in particular by taking into account their spatial and temporal context.

5- The behavior of things
Rather than assign behavior uniquely to that which is living, we analyze and imagine it for objects, dispositifs and environments in order to equip them with the "living" faculty for action and reaction, in relation to their context and their public.

Methodology and modes of appreciation and publication (EnsadLab Research Program DiiP)

Artistic dispositifs cannot escape their socio-technical conditions; to the contrary, dispositifs implement and try out these very conditions. By closely linking research and creation ('R&C'), our program explores prospective dispositifs with underlying artistic, societal and technological concerns. Researchers question, experiment and develop - through practice - new modes of representation and action, in particular those related to new information and communication technologies. The relationship with these technologies is neither that of submission nor condescension: far from being fixed tools that are used, they are dispositifs to be operated.

The collective approach to the experimentation and analysis of these dispositifs bears as much upon their composition, arrangement and technicity as on the situations that they generate and their social impact. This approach resonates with certain academic research methods - state of the art, analysis, positioning, identification of objectives and locks, resolution and new use hypotheses - while following a recursive, iterative process rather than a linear one. Testing activities take place at each step and are carried out in a precise way on both an individual and collective basis. In maintaining a constant dialogue between these two approaches - generic and specific, collective and individual, deductive and inductive - program researchers are able to construct a methodology that combines research and project creation, entitled 'Research and Creation', or 'R&C'.

The resulting creations are elaborated according to generic dispositifs and concerns that are easily shared, theorized and transferred. In order to report on and add value to these research activities, we publicize them in various ways such as exhibitions, demonstrations, conferences, seminars and workshops, as well as producing and diffusing posters, texts and images. From the moment our research leads us to develop new forms of instrumentation (in terms of both software and material), we work on its transferal to either the public domain (free license) or the industrial one (patent, etc.). We consider these different modes of issue to be 'publications', in the sense that to publish something is indeed to render it… public.

An example is the research on "Large Group Interaction", which considers a specific collective situation; the interaction of a group, in a given place, on and with a common dispositif, a proposal that raises issues of both a social and technological dimension. In order to implement and experiment a dispositif of this nature, an artistic project was elaborated: Discontrol Party, or a party within a control dispositif, based on the idea that the technology used for collective interaction (RFID, computer vision…) is also used for the tracking and control of individuals. However, this technology is thrown into chaos if the bodily movements and relationships are undisciplined and misbehaved. To pit these forces against one another, while seeking a visual result for its actors and spectators, is thus not only a public experience - both artistic and societal - but also a political one.

Discontrol Party, version 2, La Gaîté Lyrique (Paris), 25 June 2011 (Photographer: Alain Declercq)

Discontrol Party

Festive interactive dispositif, 2009-2011
Directed by Samuel Bianchini
Musical programming: Sylvie Astié (Dokidoki)
Project developed within the framework of the "Large Group Interaction" research program at the EnsadLab/DRii, laboratory of the l'École nationale supérieure des Arts Décoratifs (Ensad), Paris, and the University of Valenciennes and Hainaut-Cambrésis (France), with the support of the Agence Nationale de la Recherche (ANR) and the Maison européenne des sciences de l'homme et de la société (MESHS), Lille. Part of the research program "Practicables - artistic dispositifs: setting the stage for audience participation".
Supported by the Cap Digital Competitivity Division and the Ile de France Region within the framework of the program Futur en Seine 2011, in partnership with the Gaîté Lyrique.

• **Researchers, teachers and experts (EnsadLab Research Program DiiP)**
- Program Director: Samuel BIANCHINI
- Seminar, publication and theme "The behavior of things": Emanuele QUINZ
- Technical manager: Cyrille HENRY
- Projects and exhibitions manager: Thierry FOURNIER
- Engineering and web manager: Yann CREAC'H
- Theme "Situated interactive Narratives": Dominique CUNIN (coordination), Jean-Louis BOISSIER (seminar)
- Theme "Interactive light": Annie LEURIDAN (coordination)

• **Partners :**
Idex Paris Sciences et Lettres (PSL*), Université Paris 8 (Labex Arts-H2H), Georges Pompidou Centre, Paris, École supérieure de physique et de chimie industrielles de la ville de Paris (ESPCI), Espace des sciences Pierres-Gilles de Gennes, Paris, Sciences Po, Paris, SPEAP (Program on artistic and political experimentation) , Computer Laboratory of Lyon (Liris), Computer Laboratory of Grenoble (LIG), Tokyo University of the Arts, Graduate School of Film and New Media, Institut IAMAS, Gifu, Japan, Entreprise Orbe, Paris

• For further EnsadLab Research Program DiiP detail : http://diip.ensadlab.fr

Appendix 2: Hexagone Scène Nationale de Meylan / Rencontres-i / Atelier Arts Sciences

Antoine Conjard, Director

Overview

Hexagone Scène Nationale is a 560-seat theater located in Meylan, in the Grenoble area (France). Our mission is to stimulate and showcase artistic research, contemporary creations and to investigate cultural actions.

Hexagone Scène Nationale presents between 30 and 35 performances a year to 25,000 spectators. Our scope of interest includes all areas of performing arts including theater, music (traditional and academic music, jazz, French chansons, contemporary music), dance, street art, circus, ... One half of the shows presented are fringe creations.

Hexagone is the main organizer of the Rencontres-i Arts Sciences Biennale, a ten-day event assembling 20,000 spectators and reaching 200,000 people in the streets of the Grenoble area.

Jean Therme, Director of CEA Grenoble, Michel Ida CEA Open Innovation Director, Antoine Conjard, director of Hexagone was the initiators in 2007 of the Atelier Arts Sciences reached in 2011 by Laurent Chicoineau, director of CCSTI (Center for Scientific, Technological and Industrial Culture).
This research activity, combining artists and scientists, is based on R&D activities at one of the three major nano and microtechnology research clusters in the world and located in Grenoble. CEA is a French government-funded technological research organisation. A prominent player in the European Research Area, it is involved in setting up collaborative projects with many partners around the world. The Atelier Arts Sciences operates in accordance with the principle of open innovation binding technological research, corporations, design schools and human sciences.

AAS plans its actions on a perspective, that of a future in which technology will always be at the service of humans. It is thus a new form of humanism that is being promoted, based on the advances of knowledge and on the potentialities brought by new technologies. The idea is to invite artists to make use of their creative capacities in direct contact with cutting edge technologies as well as scientific methods and discoveries. As Gilbert Simondon has said, the aim is to "contribute the tools that Man may use to think about his own existence and his position in relation with the world that surrounds him". This contribution can also come, in a poetic way, to question modern day stereotypes and myths that sometimes gravitate around new technologies, such as the utopia of human enhancement into cyborgs or the future enslavement of humans, submitting to machines endowed with superior intelligence.

AAS works at sharing knowledge and technological research with all, in a universalist approach that excludes none, whatever may be the social, economic, geographic, religious and philosophical conditions and attitudes of each person. Thus, it maintains its action in a French republican perspective of laïcité.

Hexagone, in partnership with local universities, has been the initiator of the Atelier of Imagination.
Hexagone, in partnership with local universities, has been the initiator of the Atelier of Imagination.

Projects:

The Atelier Arts Sciences organizes research and creative residencies bringing together artists and scientists around two axis:

- an axis involving devices based on technologies developed at the CEA: motion capture and human-machine interface with Annabel Bonnery and the Motion Pod by Movea, interface gloves with Ezra and LOS, software by Adrien Mondot and his E-motion software, new lights by the artists Pascal and Aurélie Baltazar, Ravelli and Castagna,

MicheleTadini and researchers at Leti and Liten, key research institutes in nanotechnology and innovation.

- an axis of anthropology around the *New Insights / New Writings*, creative writing residency with Daniel Danis, and the *Les pieds qu'on a dans la tête* (Feet in Head) project with the Ateliers du Spectacle N+1...

Since 2007, twelve résidencies have been carried on.

By introducing human sciences into technological research, the Atelier of Imagination implements a cultural action in the field of research. It unfolds in a seminar over a period of three years. In this first year of the seminar, 50 partners of the Biennale and 50 students in innovation are investigating the theme of 'short circuit' imagination.

Residencies:

In accordance with scientific and artistic awareness, a program of meetings and laboratory visits (CEA, University and University Hospital Center/CHU) is put in place for artists. Following an initial investigation, a research program is set up: defining deliverables, research protocol, time frame and resources. The Atelier Arts Sciences provides financial support to artists to be able to work with scientists. Results are presented to the public during the Arts Sciences Biennale.

The residency is composed of three to five-day long research sequences. The number of sequences depends on the project and can cover a period of two years.

An epistemological follow-up is published in the Cahier de l'Atelier.

Since 2007, twelve residencies have been completed or launched.

Scientific Research:

- Dominique David, Engineer at SUPELEC, PhD in signal processing, Habilitated Research Director, senior expert at CEA, is the scientific coordinator for the Atelier Arts Sciences activities. Each residency calls for researchers from the CEA and partner laboratories, who are experts in the field of the on-going research project.
- Angelo Guiga, Researcher Technician at CEA
- Thierry Menissier, Professor of Philosophy at University Pierre Mendès France/UPMF,
- Luc Gwiazdzinsky, Professor of Geography at IGA-Pacte-University Joseph Fourier
- Fabienne Martin Juchat, Professor of Anthropology studying movement, Director of ICM University Stendhal Grenoble 3.

Other activities:

Each year in October, the Atelier Arts Sciences presents Experimenta, a show of new technologies for live performances and creative industries. Artists, scientists, manufacturers,

students.... showcase their devices, objects, their projects under way. Professional meetings are organized along with the show.

Resources:

The overall annual budget for the arts sciences activities is € 1.5M including contributions from the state and local authorities: Rhône-Alpes Region, Department of Isère, Grenoble Urban Community, City of Meylan and contribution in assets and the CEA staff.

Human Resources:

Six full-time employees

Ten part-time employees sharing three full-time jobs

Careers:

I do not believe that we can talk about "arts-sciences" as the rise of a new field of activities. What can be more relevant to investigate are the intersections and exchanges sparked by the collision between different fields. Not considering activities involving arts and sciences as one separate entity, allows us to maintain flexibility, agility and openness. It also enables us to work with exceptionally solid experts in their research field and to associate them to a certain project for a defined period of time. On the other hand, the encounter between arts and sciences is moving different arts disciplines towards transmediatic forms.

Interaction between artists and scientists generates new jobs in performing arts. We can find Directors for Digital in the world of theater, visual arts, dance...

With regards to research, establishing a distinctive field of "art-science" seems to me counter-productive.

Further resources:
While developing a new device, tool or concept, requires a separate research environment for the artist and scientist, one of the major resources lies in the bond that we will be able to build with the public, within the local region. Experimenta and the Rencontres-i Arts Sciences Biennale therefore offer possibilities to meet the audience, indispensable for the evolution of the projects. Intersection between arts and sciences, only has a meaning with regard to its social impact.

Impact:

The arts-sciences framework that we have set up with the CEA Grenoble and the 70 partners of the Rencontres-i, has, over the past ten years, become one of the major meeting points between performing arts and the world of science and technology, in France.

Twenty or so objects were developed, but we still have not found a way to enhance their value in the world of manufacturing.

The Cahiers de l'Atelier is a published resource, providing new and useful insights to people who conduct research in the fields that are covered in an issue. It also gives an overview of the interaction between artists and scientists. It is extremely difficult to trace tangible results of our activities. Besides producing objects, the main outcome of our projects lies in a series of serendipities triggered by this joint research: creative possibilities, established convergence, unfettered investigation of the expected results, offset with regard to pre-set objectives in a laboratory. Several residencies show examples of sparking new views on a given research, guiding the way a research is conducted or triggering unexpected collaborations between very different fields, a few years later. Poetic exploration of a limestone quarry induces research on cogeneration systems used in lime production; the CEA-Leti-Spice laboratory steps out of their usual methodology of conducting research and develops a device which allows direct paint holding based on a light-weigh system; a collective discovery of the history of energy in Grenoble opens the way towards a new tourist venue; exploring new forms of human/machine interface allows to see future forms of storytelling, a glimpse toward a 21st century cinema/theater...

Lesson:

What works well? The main lesson that we have drawn from our experiences is that devices and methods behind cultural and artistic actions are efficient and productive. Every, single person can have access to them:

1. Friendly environment: far from the stress behind the research conducted under the pressure of immediate results, research is carried out in a pleasant, reassuring environment, which boosts confidence
2. Respect: mutual desire for excellence, diversity of professional and educational backgrounds, awareness of working for the common good, respect of each and every project partner. Participants are driven by curiosity, agility, discovery and knowledge, rather than by a desire for signs of distinction and institutional hierarchy
3. Poetics: for intellectual nourishment and art of living
4. Imagination: for entry to the real world

Results:

- Motion pod by Movea adapted to live performances

- Poetic Mechanics by EZ3kiel, presented at Palais de la Découverte-Paris, Pavillon Rhône-Alpes, World Expo 2010 Shanghai

- Chromatophore, practical realization of the mathematical definition of chromaticity diagram

- International tours of shows and devices by Adrien Mondot

- Recognising and involving art into the innovation ecosystem in Grenoble

- Bonds between artistic and scientific research, technological and social innovation

Biggest challenges:

Differences in thinking, barriers between the worlds of scientists, academics and manufacturers, thinking in silos, divergence regarding public interventions, crisis of hope across Europe

Forthcoming projects:

Implementing the New Insights / New Writings program

Creative writing residencies for several authors inspired by meeting with scientists, setting up and deploying stage production

Appendix 4: IMERA
Roger Malina

Direction

Director: Position vacant, search under way

Executive Director: Emmanuel Girard Reydet; Associate Director, Pascale Hurtado

Scientific Director: Samuel Bordreuil

Scientific Activities Steering Committee:
http://www.imera.fr/index.php/en/organisation/steering-commitee/list/29-le-comite-de-pilotage.html

IMéRA was founded in 2007 as a not-for-profit organisation (Association Loi 1901) by the then three universities of Aix-Marseille and the CNRS (French National Research Agency). It was transformed into an Aix-Marseille Université (AMU) foundation on 1st January 2013.

The aim of IMéRA Foundation is "to contribute to the emergence and development of world-class multi-, inter- and cross-disciplinary research approaches and to make young researchers familiar with such approaches on the territory of Aix-Marseille University" (extract from the Foundation Statutes).

Its initial, public and private founding members are:

- Aix-Marseille University (AMU),
- the French National Research Agency (CNRS),
- the French National Institute for Health & Medical Research (Inserm),,
- the Higher School of Social Science (EHESS),
- NCC PARTNERS

The governing body of Foundation IMéRA, which is ruled by Article L719-12 of the Code of Education, is currently being set up (Aix-Marseille University President [Vice-Chancellor] Yvon Berland has asked Pierre Livet to help him through the first stage of the process).

The Foundation includes a Management Council and a Board, which itself relies on:

- the Scientific Organisation Committee responsible for routine organisation of residencies and other activities, working out calls for participation and selecting residents,
- the Foundation's Scientific Council whose members are international personalities responsible for assessing the Institute's activities.

The Foundation is represented by a President appointed among its members, and its activities are developed by the IMéRA Executive Team.

The Management Council will include AMU members in their own capacity, representatives of the Founding Members and qualified personalities with experience of trans-disciplinary work.

As a Member or RFIEA, Foundation IMéRA implements a research and organisation policy in accordance with the Charter of Institutes for Advanced Research. Its orientations and Annual Report will be subject to approval by the Aix-Marseille University Administration Board.

Strategy

IMéRA residencies take place in an atmosphere of collegial interchange, in a space that is appropriate both for nurturing cross reflections on the research work of participating scientists and for starting or strengthening inter- or trans-disciplinary cooperation: it is by monitoring science and art as they are being made and at their most intense that one can grasp and test cross-fertilisation opportunities and ensure that they connect theoretical inventions and research practices, hitherto carried out separately.

IMéRA offers resident researchers the right environment for the advancement of their research work, as close as possible to the course they have charted for themselves that fits their needs, and in line with the canons of excellence that identify them. The Institute provides an experimental, inter-collegial space where researchers can expose their works' progress to one another in seminars that may be organised by a resident on his/her research project, in collaboration with AMU teams, or on the basis of a theme chosen in common by residents.

These various contacts give each researcher the opportunity to develop new lines of enquiry that have not previously been raised in their field.

These exchanges can either show that certain issues are more common across disciplines than was imagined, or help to explain why the approaches of various disciplines are significantly different—in which case the matter can be discussed and comparative analyses made.

The practical concept that guides us is that bringing inter-field audiences together will allow scientists to reappraise their research work and the logic underlying its argumentation, and therefore to detect cross-fertilisation points for future joint disciplines.

Some approaches to IMéRA's cross-disciplinary policy

Our scientific policy is light years away from an approach that might encourage cross-disciplinarity per se and for its own sake, as some ideal model to be achieved (at last…).
On the contrary, we are of the opinion that instead of following its dictates blindly, as a matter of principle, it is more realistic and effective to ground our research in the current state of scientific knowledge and to anchor the possibility and necessity of cross-disciplinarity in the reality and current progress of such knowledge.

In particular, given the inevitably confused and intricate nature of research work now in progress, IMéRA's aim is to focus on the disciplines that have been led—precisely as a result of their breakthroughs—to use resources, be they theoretical or practical, in contexts far removed from their usual domains.

We welcome all manner of cross-disciplinary relationships…

For that purpose, our strategy is to broaden our focus to include diversified forms of cross-disciplinary relationships and their various effects:

- "Past" interactions (for instance through a history of cross-disciplines) or present interactions;
- Interactions taking place and developing without hype, as where conceptual patterns ("structure," "network" or "morphogenesis" to name but a few) are adopted more or less simultaneously by several disciplines;
- Interactions taking place in a more assertive way, as where the appearance of new intermediate objects means that it is no longer possible for certain disciplines to claim exclusive ownership of specific concepts (for instance "argumentation," whose relationships to "proof" must be clarified);
- Interactions taking place when new science continents emerge (we are thinking of neuroscience and eco-science here) whose rapid development gives leads to a shift—or even a realignment—in connected disciplines (for instance, how can mindsets shaped by historical research adapt to accommodate the notion of "societies' environmental footprint"?).

... not only within science but also between art and science…

- Some interactions bridge fairly slender gaps between disciplines (for instance, in social science, between sociology and contemporary world history); others, conversely, pull together initially very distant research domains (e.g. the world of art on the one hand and hard science laboratories, such as physics or neuroscience, on the other) so that they come to share a point of contact. During IMéRA's first residencies, many projects hinging on digital instrumentation thus triggered new research practices by scientists and artists, who took part in innovative cooperation schemes.

Lastly, interaction can take place through "shareholding" in wider enterprises set up outside the academic world and focusing, for instance, on the circulation of knowledge—therefore aimed at a wider audience—while nonetheless remaining of interest to the academic world. This results in a broadening of the range of residents' disciplines and required skills, be they scientific or artistic, through dialogue. Residency project themes bear on several domains that will inevitably overlap: -- circulation of conceptual patterns (including possible effects of retroactive restructuring);

- emergence of new research fields and new interrogations;
- new research instrumentation systems;
- definition of new scientific objects;
- initiatives connected with the circulation and reception of knowledge.
- … and our aim is to test their potential.

However the goal of IMéRA is not merely to observe and analyse the various cross-fertilisation and interaction dynamics between disciplines. On the basis of that analysis, we strive to build an experimental space aimed at reinforcing such dynamics as described above, so as to make its observation, analysis and testing more incisive and significant. This is what we have tried to achieve in the last four years. From this perspective, IMéRA can best be defined as a"Laboratory for Cross-disciplinary Dynamics," for exploring the forces that push and/or hinder such dynamics, the varied forms these dynamics can take and, lastly, the strength of the "mixed compounds" that are part of it.

Projects

The IMERA program is built around the projects of the residents. During the residency, IMERA organises workshops and symposia around the topics being researched by the resident.

Examples include:

- Artist Bryan O Connell, of the San Francisco Exploratorium, who has carried out projects in the context of Marseille 2013 European City of Culture around the GR13 Hiking trail project of site specific art=science projects:
- http://www.imera.fr/index.php/en/component/resource/article/les-residents/4-ils-sont-pr%C3%A9sent-%C3%A0-lim%C3%A9ra/619-bryan-connell.html
- Rachel Mayeri; Cinema for Primates with the Primatology Research Lab
- http://www.imera.fr/index.php/en/component/resource/article/2-les-residents/98-rachel-mayeri.html

- Artist Etienne Rey: In collaboration with neuroscience researcher Laurent Perrinet.
- http://www.imera.fr/index.php/en/component/resource/article/2-les-residents/228-etienne-rey.html

IMERA does not conduct projects as such. However through the projects of the residents a number of multi-year themes are explored in depth.

- Of particular note is the Frontiers program run by Cedric Parizot, member of the IMERA Scientific Animation Committee: http://www.imera.fr/index.php/en/component/sportingevents/event/232-atelier-matrialisation-dmatrialisation-des-frontires/62.html

which in its methodology includes artists in all its activities, and also a collaboration with the Art School of Aix en Provence.

Scientific research

One Originality of IMERA Art- Science program is that it hosts scientists in residence on art-science collaborations. Scientists in residence have included:

- Nano Scientist Jim Gimzewski: An Art/Sci Exploration of Creativity and Imagination in fields of Nanotechnology with artists Pierre Alain Hubert, Victoria Vesna and others: http://www.imera.fr/index.php/en/component/resource/article/2-les-residents/86-james-gimzewski.html
- Physicist Bruno Giorgini: On the Physics of the City with Artist mariateresa Sartori: http://www.imera.fr/index.php/en/component/resource/article/2-les-residents/292-bruno-giorgini.html
- Ciro Catutto: Complex Networks scientist with a team around Data-driven Exploration of Dynamical Networks): http://www.imera.fr/index.php/en/the-fellows/2010-2011/article/les-residents/8-les-residents-de-linstituts-20102011/185-quipedynamical-networks.html
- Nicola Mai, Anthropologist an experimental documentary film about the humanitarian governance of migrants who are potentially vulnerable to exploitation and abuse in relation to the sexual domain: http://www.imera.fr/index.php/en/component/resource/article/les-residents/4-ils-sont-pr%C3%A9sent-%C3%A0-lim%C3%A9ra/433-nicola-mai.html

Inferface to education

Aix Marseille University has recently established an undergraduate degree in Science and Humanities (http://formations.univ-amu.fr/ME3SHU.html) The program is very innovative as the syllabus is theme based and involves team teaching. Several faculty members serve on the IMERA scientific activities steering committee.

IMERA specifically seeks also to provide a supportive context for PhD students and post doctoral researchers whose research crosses disciplines.

A study group led by Professor Paola Cantu is analyzing case studies of inter-disciplinary work and is seeking to establish theoretical and practical analyses to support such practices.

Challenges
1. The IMERA budget includes budgets for workshops and collaboration but not project budgets to realize art works or external projects. As a results artists in residence must find external funding.
2. IMERA must supplement its base budget with additional funding sources to ramp up the residency program to host at least 200 person=months of residency per year. In the current funding climate this is a major challenge.
3. As a University Foundation IMERA seeks to interact with the socio-economic world. One private company, NCC Partners, is a founding member of the foundation. How to develop viable interactions with companies and external non profits will be a key goal of the coming years.
4. The Art Science residency program has been very active and productive but developing success criteria for such collaborations is a key challenge. IMERA will be reviewed externally and has been asked to develop evaluation criteria for art-science projects.
5. IMERA seeks to develop its program in the Mediterranean context, in particular the southern Mediterranean. Given the scientific, economic and other 'asymmetries' achieving a strong southern Mediterranean program will be a challenge in the coming years.
6. IMERA seeks to enable collaboration between the social sciences and humanities with the physical sciences. Such collaborations within the sciences but crossing the social sciences and humanities to hard sciences presents particular challenges. (The Frontiers initiative is a promising example).
7. IMERA seeks also to interface with the world of training, particularly at the doctoral and post-doctoral level. This presents institutional and funding challenges.

Appendix 5: IRCAM

Hugues Vinet, Scientific Director

Introduction to IRCAM

IRCAM (Institut de Recherche et Coordination Acoustique/ Musique) was founded by composer and conductor Pierre Boulez in 1977 as part of the Centre Pompidou project, with the goal of setting up a place of experimentation where « scientists and composers explore together and systematically the sound possibilities and limits related to electronic techniques ». Through its numerous evolutions over the 35 years of its existence, under the successive directions of Pierre Boulez (until 1991), Laurent Bayle (1992-2001), Bernard Stiegler (2002-2005) and Frank Madlener (since 2006), IRCAM has remained the largest public research institution worldwide dedicated to music and sound, while developing its activities beyond contemporary music creation to various fields in the society (performing arts, education, music and multimedia industries, virtual reality, sound design, etc.).

Figures and facts
- 150 permanent collaborators

Artistic production:
- 30 new works created every year;
- 55 concerts and international tours every year;
- Main yearly communication event : the ManiFeste festival in June.

Research:

- Joint research unit with CNRS (Centre National de la Recherche Scientifique), UPMC (University Pierre et Marie Curie) and Ministry of Culture and Communication, entitled STMS (Science and Technology of Music and Sound);
- 100 collaborators (researchers, engineers, technicians, PhD students) plus 40 visitors (researchers, composers in research, interns) every year;
- 50% of self-funding (including permanent staff) through national and international R&D collaborative programs and technology licensing;
- 7 research teams specialized in various scientific fields (acoustics, digital audio signal processing, computer science, cognitive psychology, musicology);
- 150 publications every year (journals, conference proceedings, books);
- 9 software environments developed, supported and distributed : Max, Modalys, AudioSculpt, Spat, OpenMusic, CataRT, OMax, Antescofo, Gesture follower, most of them available through the IRCAM Forum. The Max software, developed by the Cycling'74 company in San Francisco, with its 20,000 registered users, has become a world standard for multimedia interaction.

Education:

- Hosting of the ATIAM (Acoustics, Signal Processing and Computer Sciences applied to Music) Masters 2 course in collaboration with UPMC and Télécom ParisTech (20-25 students every year);
- Organization of higher education courses for artists in computer music (20 students) and sound design (12 students).

Key factors of art-science interaction and research at IRCAM

The status of technology development

Technology appears as a canonical support of interface between art and science at IRCAM. It is the support of incremental integration and assessment of all research activities in the field of engineering. The software environments resulting from the research are used by artists as creation tools, providing new ways of production, manipulation and representation of the sound material, as well as the support of interactive works. Mastering the technological side is then a key success factor of any art-science project; this has strong implications in the organization at IRCAM, both in the research and production sides: the research teams host professional developers who are in charge of integrating the research results into software environments made

available to the artistic community and supported in the long term. A specific category of collaborators, Computer Music Designers, are associated to all artistic productions in collaboration with composers and are responsible for the technical setup from the early experimentation phases until the concert production.

The development activity produces two main kinds of technical objects :

- functional modules, which can be seen as black boxes that encapsulate a model, or an algorithm through a well-defined programming interface; they are also the main support of industrial transfer;
- open environments, which enable the combination of a number of functional modules through dedicated user interfaces and computer languages. The goal is to propose toolboxes as open as possible to any artistic approach. Examples of such modular and programmable environments are Max, OpenMusic, Modalys.

An unfortunately common issue related to the status of technology in art-science projects, is that it may appear as the main justification of the artistic work, or even as a trap whose mastering has concentrated most of the composer's energy at the expense of the development of strong artistic ideas. The approach promoted at IRCAM on this subject is at the opposite of any positivism: the technology is at the service of the artistic purpose, it must be fully mastered and integrated, possibly up to its complete disappearing to the audience, with the potential difficulty of eliciting its role and justifying its cost.

Organization and modes of interactions between artists and scientists

The organization of IRCAM comprises four main operational departments : R&D, Creation and Diffusion, Education and Cultural Outreach, Research/Creation Interfaces.
Whereas researchers and engineers are hosted in the R&D department and represent an important part of the permanent staff, the main frameworks for hosting invited composers and other artists as independent collaborators are :

- productions in studio, targeted to the public execution of the premiere;
- composers in research or in residence, who are hosted in research teams for an experimental work, possibly in preparation for an upcoming production;
- thematic workgroups, gathering present artists, computer music designers, researchers and engineers, on various live topics such as rhythmic representations, computer-aided orchestration, gestural control.

The Research/ Creation Interfaces department is in charge of coordinating the interactions between artists and R&D, the user feedback for the software development and its distribution to the IRCAM Forum.

This organization defines a clear split of activities and competences between the departments; the impact of any joint art-science project is then assessed in each department according to its own rules : scientific publications and industrial transfer for R&D, audience and critiques for artistic creation, media coverage for both.

Research area, management of interdisciplinarity and institutional support

The research area is defined by the STMS[1] lab acronym. Its broad spectrum of investigations, going from physics (acoustics) to humanities (cognitive psychology, musicology) with a center of gravity in information technology (digital signal processing, computer science – languages, multimedia systems, human-computer interaction), is necessitated in order to address all required knowledge facets aimed at understanding and contributing to contemporary music creation.

The R&D department is organized in 7 specialized research teams, each team being in charge of all activities related to its research area : fundamental and applied research, development, artistic applications, collaborative projects, industrial transfers. Each team participates and is expected to be a recognized contributor as part of an international scientific community.

This original positioning of the IRCAM R&D department, together as an interdisciplinary interface lab with a strong connection to the cultural area, and as the gathering of research teams, each one being identified as an actor in traditional research fields, has been a key factor of support of French national institutions of research and higher education, the CNRS, the UPMC and the INRIA: in 2012, the STMS lab includes 10 permanent collaborators from these institutions.

Extensions to new activity fields

In addition to this increased institutional support, IRCAM has extended its activities over the last 20 years by developing an expertise in new research directions, much beyond the initial framework of contemporary creation, thanks in particular to the support of national (through the French agency ANR) and European R&D programs (mainly ICT and FET) and as an answer to broader societal needs: music information retrieval, sound design, intermodal cognition, web audio technologies, etc. The developed projects have enabled industrial collaborations and technology transfers in new fields, extending the mainstream of experimental environments for creation and tools for music and audio production, such as proposed in the recent and award-winning IRCAM Tools collection. Conversely, the concepts and technologies issued from these projects often proved to meet a great interest in the artistic community for the renewal of the existing tools and approaches.

Attractivity

A key factor of IRCAM's attractivity in the artistic field lies on the exposure it provides to young and confirmed artists. A strong connection to the cultural scene, in the tradition of the great composers of the 20th century, and its exposure to the media, are the main conditions for attracting talents. On the research side, the concentration of scientists representing a large spectrum of disciplines in direct connection to contemporary creation makes the IRCAM Lab a

1 Science and Technology of Music and Sound

unique place for engineers and researchers attracted by music. The Computer Music Course and the ATIAM Master are the main higher education courses proposed to students respectively in composition and in engineering sciences, interested in joining IRCAM.

Directions for future development

Doctoral curricula for composers

The evolution of the French higher education system in conformance to the Bologna Accords is currently ongoing. Agreements between universities and conservatories are starting to be discussed and implemented, in order to propose Masters and doctoral degrees for performers, composers and computer music designers. It is expected that these evolutions will enable the creation of permanent positions for these categories of actors.

Towards a better recognition of the role of artistic creation in society

Institutions like IRCAM have shown that a research dedicated to artistic creation could have a broad impact to the society, not only in its contribution to building today's culture, but in all activity fields involving sound technologies: games, simulation and virtual reality, multimodal human-computer interfaces, multimedia search engines, etc. Media artists have soon anticipated technological innovations in visionary works, as it has been shown for instance by Golan Levin. So it is hoped that the role of artistic creation in society will be better and better recognized and supported in particular by academic institutions and research funding programs at national and international levels.

Appendix 6: LIMSI-CNRS/VIDA
Nathalie Delprat

Activities

VIDA (Virtuality, Interaction, Design, & Art) is an art-science thematics at LIMSI (Computer Science Laboratory for Mechanics and Engineering Sciences), which is a scientific research laboratory of the CNRS associated with two universities (University of Paris Sud and Pierre et Marie Curie University). As a transerve action of the Human-Computer Interaction Departement, VIDA gathers permanent researchers, PhD students, and engineers working on short or long projects with creative professionals (artists, designers, architects..) and is also responsible for organizing events such as art-science workshops or seminars (Interferences_VIDA).

Projects
Since 2006, more than 25 projects have been developed or are still under progress. These projects covers 3 main themes: Virtual Augmented Reality (for the performing arts, architecture and visual arts), Multimodal human-computer interaction (for social life, music, dance, or theater performance) and Virtual materiality (for cognitive experiments in arts and sciences). Due to the

considerable diversity in the project themes, objectives, in number of involved persons or in the funding types, it is not possible to give the outlines of a typical VIDA's project.

Artistic residencies

No artistic residencies at LIMSI

Scientific research

Most projects developed in VIDA have been published either in scientific journals or conferences with art tracks (CHI, ACM Multimédia...) and also in specialised art-science journals (Leonardo, IJART,..).

Permanent researchers, PhD students and postdocs are working in this research activity .

Other art-science activities that you consider important for your institution

In addition to publishing or scientific conferences, VIDA dissemination includes artistic events such as live performances, exhibitions, concerts in artistic festivals or galleries and art-science mediations in public space.

Funding resources

Funding resources are very diversified: ANR projects, regional support, art-science calls, marginal funding sources...

Human resources

There is no position at LIMSI that formally dedicated to VIDA. However some permanent personal or doctorate students spend some of their professional activity on VIDA (from 10 to 50% approximately)

Career

It is difficult to consider such a career for a scientific researcher in France, except in few institutions or laboratories dedicated to art-science. To develop an art-science approach means to struggle against prejudices from scientific community, resistance from institutional environments (education and research) and to find new ways to integrate this approach in more conventional projects. It is highly profitable when it works but very difficult to perform.

Since more and more conferences in some domains such as computer sciences have art-science tracks, it is possible to combine art-science publication and promotion of standard scientific activity.

The main features are interdisciplinarity, creativity, personal interest in culture and mediation, individual determination, time and money(!)"

Other resources than funding or human resources that contribute to the sustainability of your activities

Internships, annex activities of PhD students, art-science applications of fundamental research (that can be funded as regular scientific projects)...

Impact

- new research topic exploration, scientific publications
- artwork productions
- web presence with the artsciedu diffusion list and web site VIDA
- creative engagement through cultural events
- contributions to the art-science-society debate

Lessons: what works well...

- VIDA as a catalyst for collaborative experiences with design or fine art schools and other scientific institutions.
- VIDA as a giving to LIMSI an art-science image that can help to integrate or develop other art-science projects in our close environment (eg La Diagonale, A&S Days at UPSud...)
- VIDA as a place for creative productions with artists or cultural associations from various areas (theater, dance, music..).
- VIDA as a natural tool to create or strenghen collaborations both within groups and between members of different groups at LIMSI.

Lessons: and what doesn't really work!

- To be better integrated in the scientific community
- not to be considered by some artists only as a technoscientific support
- bridge with other educational institutions

The major difficulties that you experience in your activities...

- work valorization
- high impact journals for art-science research dissemination
- resistance from colleagues
- political recuperation of art-science activity from some scientific institutions or foundations for marketing and communication

Suggested actions you would like to make to stakeholders of your institution or of other art-science places

- To give the possibility of long research projects and not to operate only on the basis of short collaborations or in the context of very definite project calls
- Valorization of the risk-taking in new approaches through Art&Science projects
- specific fundings for art-sciences innovations (phD grants, post-doctoral missions)
- support to cross-disciplinary researches between engineering sciences and humanities
- have specific installations and spaces inside a lab for the development of A&S projects and artistic residencies

Major projects for the upcoming years...

- To pursue the development of an art-science thematics in a scientific laboratory and to export this experience in other labs.
- To bring young artists and scientists to art-science and encourage them to enrich their education through art-science experiences (approach, production, collaboration)
- To propose new educational perspectives and new form of scientific mediations

Main obstacles:

- to change the perception of scientific institutions and universities towards art-science
- disciplinary evaluation of scientific research
- fundings
- in-lab hosting

The aim is not to dissolve disciplinary boundaries, nor to create a new discipline: creativity in art-science relates to the process of crossing these boundaries from an unexpected and original way. This is the reason why it is a challenging question to define the perfect environment for art-science development without delimiting and restricting it. The art-science approach offers a collaborative process, which allows for shared understanding and creation and facilitates a cross-cultural dialog, including the public.

Mapping Space: Introducing Geographical Information Systems in Indian School Classrooms

http://wp.me/P2oVig-i5

Coordinator: Anu Joy

This proposal explores the potential of Geographical Information Systems (GIS) as an instructional tool that can support authentic inquiry practices in school classrooms. GIS can be used as a pedagogic tool in school classrooms that can help children conduct systematic investigations on their familiar everyday world and create databases on regional specificities in collaboration with their peers, teachers and experts of various disciplines. One of the larger goals of this proposal is to develop research-based content and innovative pedagogies for multidisciplinary teaching-learning in schools that take into account the nature of the learner, of the learning process and of the subject matter. The paper reflect briefly the current status of technology-enabled learning in Indian school classrooms and suggest actions to implement GIS as an instructional tool as part of the regular Indian school curriculum.

Authentic inquiry as a context for creative teaching and learning

Authentic inquiry[1] plays an important role in creative learning. This proposal explores the potential of Geographical Information Systems (GIS) as a pedagogic tool to guide authentic inquiry practices in Indian school classrooms. GIS can be used to map and represent a complex environment by examining its multiple aspects and tracking several entities in it at the same time. It can function as a motivational and optimal tool for learning of multiple disciplines. Also the process of map making can guide children through iconic, enactive and symbolic modes of learning, which according to Bruner (1966), are significant aspects of a learning process.

In the context of a school classroom, authentic inquiry practices provide scope for children to ask questions and actively construct meaning in collaboration with their peers and teachers through the process of solving problems of their complex everyday world, find new problem solving methods and formulate conclusions based on the results of inquiry (Roth and Roychoudhury 1993; Krajcik et al. 1994). Such an inquiry process can instill in the learner a set of cognitive, meta-cognitive and process skills such as conceptual understanding, problem solving, reasoning, analyzing, visualizing, modifying, inferring, deducting, creating, incorporating existing knowledge into the new inquiry, communicating the findings, and eventually arriving at one's own learning (Schwartz et al. 2004).

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1 Authentic inquiry constitutes everyday practices and procedures employed by practitioners of a discipline to solve new problems (Roth and Lucas 1997; Krajcik et al. 1994). Examinations of scientific practices and routines provided by ethnographic studies of science laboratory (Latour and Woolgar 1979) offer insights into the procedures and skills of authentic practice. This idea developed within the theoretical framework of situated cognition proposes that children engaging in inquiry practices similar to those of scientists provides a meaningful learning context conducive towards developing knowledge, methods and skills of a discipline (Brown, Collins, and Duguid 1989; Lave and Wenger 1991; Chinn and Malhotra 2002)

In this proposal the term 'authentic inquiry' denotes the multiple approaches that can be used by teachers and children in a classroom to solve a problem and reach a finding. The goal is to develop an effective framework and pedagogic method for conducting the inquiry process in a classroom and for understanding the nature of learning that happens. In doing so, it is hoped that the outcome of this project can offer methods to show how authentic inquiry can contribute to educational theory and practice, while also demonstrating how it can be an effective way to approach teaching and learning in a classroom.

Geographical Information Systems: A pedagogic tool for conducting authentic inquiry practices in school classrooms

Geographical Information Systems can be used as an educational tool to explore a broad range of spatial questions in school classrooms and support teaching and learning in an inquiry mode (Wanner and Kerski 1999; Lemberg and Stoltman 2001; Demirci 2008). GIS has the potential to integrate a vast variety of information into its geo spatial visualization. The process of creating maps and databases of the familiar everyday world can enhance children's understanding of geographical locations, their sense of space and entities in that space, direction, visuo-spatial thinking, observational and cartographic skills. It can also help children build a connection with nature and with their own localities and the entities therein. This can motivate children to take the initiative in conserving their local environment by appreciating the kinds of resources available (physical, historical and cultural) and how their own practices, usage and interventions can create an impact on the environment.

Despite this potential as well as the availability of computers in schools and free GIS software, the use of modern day tools and techniques such as GIS is practically absent in Indian school classrooms. GIS has now become an integral part of geography education in countries like the USA, Canada and some European countries, and has a significant impact on secondary education (Hagevik 2011; Incekara, 2010; Kerski 2003). The Indian school curriculum in the subject area of Social Studies includes map reading (world map, political maps, geo-physical maps, etc.), but little attention is paid to the process of creating maps. The concepts, techniques and methods of map making are not part of children's regular school curriculum, and this necessitates the design and evolution of a pedagogy and content for introducing tools of map making into school learning.

The questions and aims

The key questions addressed in this proposal are: How can we make the learners in a classroom more like a group of investigators engaged in exploring the local histories, geography, climate, environment, cultural specificities, socio-economic realties, biodiversity, agro-ecological characteristics, settlement patterns, land and water usage etc.? How can children collaborate with teachers and practitioners to acquire the fundamental concepts and skills of a discipline while exploring their familiar everyday world? How can we incorporate GIS-based teaching-learning (linked with remote sensing and other online data repositories) into the Indian school curriculum?

The basic premise of this proposal is that guiding children through an authentic inquiry process in school will equip them with the powerful tools of a discipline–concepts, skills, and methods– that will deepen their learning and understanding of disciplines (Kuhn et al. 2000; Gardner and Mansilla 1999; Bransford, Brown and Cocking 1999). It will instill in children the higher-order thinking, skills and abilities that will help them perceive and solve problems of the complex everyday world with the categories and tools offered by the disciplines (Schauble 1996; Zimmerman 2000). Such a disciplinary engagement with the world will help children to become expert problem solvers and creative learners. This proposal is also informed by the view that learning is an active and complex process, where each child is unique and has to be treated in accordance to her/his uniqueness, cognitive abilities, and pace of learning (Bruner 1977; Wood 1979). Children can learn more effectively when they take more responsibility towards the aim of a learning task.

Thus the proposal aims to:

1. Design instructional strategies and content that provides opportunities for children to conduct authentic inquiry practices in school classrooms that support them to solve problems of familiar everyday world in creative ways; also that provides scope for acquiring skills and meaningful learning of concepts of multiple disciplines in an integrated and holistic manner.
2. Involve children in small-scale research projects in collaboration with teachers and subject experts, and create information systems and databases of regional and local specificities.
3. Design and disseminate content and instructional methodologies that use GIS as a pedagogic tool to investigate problems of children's everyday world and local environment. Evolve an overall framework for instruction through the inquiry mode of learning using GIS and digital technologies, add-research based modification to the framework and identify methods of implementation in the classroom.
4. Evaluate the potential of digital technologies for school learning, and the issues and key problems in their implementation in Indian classrooms.
5. Demonstrate a model program that uses digital technologies as a pedagogic tool and show how to capitalize on the potential of such a tool for teaching-learning purposes in school.

Exemplar workshop on map making

A workshop focusing on the ways to evolve content for GIS-based teaching-learning was conducted with 18 school children from grade IV to grade VIII. The workshop introduced children to the tools, techniques and concepts of map making. It focused on directing children to discover and understand the significance of their familiar everyday world and immediate surroundings for map making. The mode of instruction included activities such as field walks, drawing maps of familiar locations and routes, familiarizing oneself with software tools, navigating with maps and GPS, and collecting data to create maps that highlighted environmentally significant aspects of a campus. During the initial sessions, children drew maps of small areas such as their homes and the surroundings, their school locality, of the route from home to a nearby bus stop/school, etc. Later, the children were guided through two projects to

track various entities and create maps using a set of icons that represented buildings, landscaping, biodiversity, and renewable and non-renewable energy sources of a 5.75 acre campus of a research institute employing the concepts learned, computers, software tools, and techniques of map making. The children identified, geocoded and databased, a total of 363 trees belonging to 82 different species, 69 genera and 33 families. They also tracked location of various energy sources such as water and electricity distributions systems, location of solar panels etc.

We consider this first workshop as a preliminary phase of exploration towards our aim of introducing GIS in Indian school classrooms. The workshop was conducted without any external funding with support of PhD student volunteers to demonstrate how existing expertise and resources of a research institute holds the capacity to conduct such summer vacation programs for school children.

The insights generated from the workshop suggest that GIS-based instructional framework can provide an authentic context for inquiry mode of learning that is centered on problem solving and that encourage children to be active agents of their own learning process. The activities clearly provided a meaningful context for children to gain authentic field experiences, collect real data about the question of interest, adding their own data to the map, create database etc. Children learned important concepts related to map making, remote sensing satellites, GIS, energy sources, biodiversity etc. as part of an effort to understand various aspects of their familiar everyday world. Learning happened through discussions, seminars, projects, activities, and working in teams. The distinct characteristics of the sessions were that it was interactive and non-hierarchical where every child actively participated, had their own roles to play, explore, observe, gather and record first-hand information, and arrive at ones own learning. The workshop did not focus on specific learning outcomes, but rather encouraged diversity in outcomes among children of different age groups, based on their ability and pace. The assessment was embedded in the learning contexts and was done while children performing the tasks. It was interesting to note that even the younger children who participated in the workshop were able to create maps and databases, use GPS and software tools, apply relevant concepts, and enhance their understanding of space, of trees and plants, etc., whereas senior/more knowledgeable children acted as capable peers who motivated and guided learning. This shows that a heterogeneous group of children of mixed ability and age can create a rich learning context and produce better learning outcomes. What the workshop suggests is that, it is possible for the curriculum to introduce the basics of GIS starting from middle school and reach GIS-based map making using software, in secondary school. Moreover the workshop helped children appreciate the importance of their familiar everyday world for learning of school subjects.

Barriers to incorporation of pedagogic innovations and inquiry-based teaching-learning in Indian school classrooms

There are persistent concerns that Indian school education is not offering learners enriched learning experiences, and not motivating or preparing them to pursue higher learning of the disciplines. What is more significant is that there is a serious lack of research on children's learning and understanding of school subjects. Such research would form the basis on which policies are formulated, pedagogic methods and content are developed and conclusions are

arrived at. There exist very few studies on Indian schooling that systematically examine the efficacy of curricular principles, policies, teaching-learning practices, and how children learn the concepts and practices of a discipline.

Inquiry-based learning has been a central theme of the educational reforms brought in by the National Curriculum Framework-2005.[2] The document expresses dissatisfaction with the prevailing educational and teaching-learning practices in schools. It proposes a critical, inquiry-based and activity-oriented pedagogy for effective teaching and learning in school classrooms, where learners must assume more active roles and teachers a facilitating role. But in reality, there exists a huge gap between the intended and the implemented curriculum. The actual teaching-learning process in a real Indian classroom is still in the era of print technology, with the textbook being the powerful pedagogical tool in the hands of the teacher and the children. Kumar (1991) calls the prescribed textbook the "defacto curriculum" as it is the prime curriculum resource that completely determines the day-to-day pedagogic activities of a classroom. The classroom learning is bookish as it involves rote learning for the purpose of the examination, and the prime goal of teaching-learning is completion of the content of a textbook and syllabus within the allotted curricular time, and testing children at the end of the year on the textbook content learned. The kind of inquiry and activities conducted in Indian school classrooms are scripted by the textbooks and syllabus developed in accordance with the guidelines set by a centrally written curriculum. Teachers follow these predetermined scripts and procedures, and whole classroom processes are confined to and dependent on the content of the textbooks. Teaching and learning are confined to the specific timeframe allotted by the curriculum and syllabus, viz. the seven period time table of a school day and the strict boundaries of each subject and classroom. In the classroom, children are also socialized to accept the pedagogic authority of the teacher, textbook and curriculum (Clarke 2001; Sarangapani 2003). The classroom instruction implemented through the teacher by the centrally written curriculum and textbooks often fails to draw children's attention to the relevance of their everyday world and immediate context for learning purposes. Therefore, it fails to develop in children the skills of inquiry, observation, reasoning and learning based on real world contexts, thus making classroom learning a 'decontextualised' experience for the children (Kumar, 1997).

Schools also introduce a compartmentalized view of the world and of disciplines in terms of methods and concepts. Inquiry, experiential/activity-based learning are predominantly associated with and conducted in the domain of science. Science is the only subject that is viewed as being amenable to inquiry, experimentation, data collection, analysis, etc. This brings in a dissonance in the learning of school subjects, where the humanities, arts and languages are seen as subjects that require memorization of facts and verbal skills, mathematics is viewed as a subject that needs logical skills, and science is the only subject that is viewed as requiring reasoning and practical skills, and a non-verbalized mode of learning.

Another important characteristic of the Indian classroom, especially in learning through the textbook, is the lack of inter-relatedness of conceptual learning across subjects and grades. There are no specific intended learning aims relating to the teaching-learning of a concept, and the

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2 National Council of Educational Research and Training (NCERT). *National Curriculum Framework*. New Delhi: NCERT, 2005

pedagogic processes fail to connect concepts from elementary to upper primary to high school. What the child learns in each grade is a set of certain previously determined concepts viewed as fundamental to a discipline, without evaluating their cognitive usefulness, the learning progress and outcomes. Newly emerging disciplines and knowledge are not included in Indian school textbooks.

Status of technology-enabled teaching-learning in schools and barriers to the use of digital technologies in school learning

The introduction of GIS in Indian classrooms for teaching-learning purposes can create new avenues for pedagogic innovations at a time when noteworthy efforts are being made by the central and state governments to formulate curricular policy and introduce Information and Communication Technology (ICT) in schools (NCF 2005; MHRD 2010). Several states in the country have launched Information and Communication Technology (ICT) as a compulsory subject in the secondary and higher secondary school curriculum.[3] As a result, schools have been equipped with computer and IT labs, internet connectivity and other related accessories. Teachers are encouraged to integrate ICT in the teaching-learning process, and in-service teacher training programs are offered to build computer and IT-related skills and promote use of interactive software.

While there is a wealth of debate, proposals and policy documents on the use of ICT in schools, there is a paucity of research and literature on the use, implementation and effectiveness of digital technologies as a pedagogic tool in Indian schools. Although the potential benefits of digital technologies for learning have been widely acknowledged in the policy documents and reports, there are no programs that have successfully put the concept into practice and integrated ICT into the pedagogic practices of a classroom and into the curriculum. The quality of the curriculum, content, facilities and infrastructure for teaching-learning through ICT are uneven across the states of the country and the different school systems. Moreover, there is a difference in the manner in which ICT-enabled learning is used in private schools and publicly funded schools, urban and rural schools, aided and unaided schools. The practical use of ICT for strengthening the teaching and learning process is a challenge even when schools possess the necessary facilities and the teachers are aware of the benefits of ICT integration and have received basic ICT training, etc. While using technology in the classroom, the focus is more on developing generic ICT literacy skills such as familiarizing oneself with a computer, key boarding, word-processing, using databases, spreadsheets and the Internet, watching visual models, documentaries, etc. The lack of research, expertise and model curricular programs in technology-enabled teaching-learning in the Indian context is a major obstacle. The poor infrastructure facilities in government-funded schools, large student-teacher ratio, and lack of

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3 One such exemplary program is the IT@School Project of the General Education Department of Government of Kerala, which was set up in the year 2000 for empowering the state schools through Information and Communication Technology (ICT)-enabled education. The project implemented ICT-enabled education in over 12000 schools in the state and put in place a system for the proper supply of computers and accessories to schools. The project works entirely on Free and Open Source Software and it is considered to be the single largest simultaneous deployment of FOSS-based ICT education in the world. In content development, the free OS, IT@School GNU/Linux is bundled with several educational software like Dr. Geo, Rasmol, K-Tech lab, Geogebra, Chemtool, Kalcium, etc. The project has also prepared interactive multimedia CDs, handbooks and training modules for ICT, as well as text books for IT in grades V to X

professional capability of teachers to incorporate new pedagogic methodologies/technologies are additional factors that contribute to the difficulties in implementing innovative curriculum projects.

Given the complexity of the education scenario in India, which includes differential school systems with diverse socio-cultural-economic-linguistic-geographic landscapes, the implementation of a new curricular project or a technological tool like GIS in schools and evaluation of its effectiveness in teaching-learning processes, is a challenging task. A fundamental challenge is the development of content and teaching-learning materials that can be integrated into the present structure of schooling, which has insufficient curricular time for teaching-learning through an inquiry mode. The large network of schools spread across different states of the country and using different languages for teaching and learning, poses a problem of scalability.

Suggested actions

In the spirit of improving research on curriculum and school education and to introduce authentic inquiry mode of teaching-learning and GIS based instruction in schools, the paper identifies seven areas for specific action. The implementation of these suggested actions are envisioned as joint responsibilities of the state, the government agencies involved in school education, institutes of higher learning, research centres and schools.

For educationalists and curriculum developers

1. Restructuring organization of school classrooms and curricular time

An instructional method that guides children through the authentic inquiry mode of learning calls for a fundamental restructuring of the school classroom in terms of its organization, teacher-student ratio, processes, time allotment, activities, resources, tool use, and also reconceptualization of the roles of teacher and children. It requires design and development of pedagogic activities, content and new teaching-learning materials, professionally equipping and empowering teachers, evaluation of the effectiveness of the teaching-learning strategies and devising methods of implementation of the different components of the curriculum in the classroom.

2. Building and sustaining academic support to schools

Developing curricular and learning experiences for school children based on the framework of authentic inquiry practices can find its purpose only when they are embedded in collaborative practices and authentic team work of teachers, educationalists, disciplinary experts, and children. In India, the schools, teacher training centres and university systems are three isolated distinct worlds and the formal organization, policies and practices of these systems reinforce this separation. Improving learning and fostering creative pedagogic practices in schools requires new ways of working in extensive and meaningful collaborative partnerships between universities, research institutes, teachers, educationalists, and children and creating a community

of experts to conceptualize and implement a curriculum. A curricular project of introducing GIS in schools requires collaboration for creating resources, evolving content and pedagogy, evaluating of its effectiveness, hardware and software support, supporting teachers and children at different phases of the project and envisioning new possibilities.

What is important is building and sustaining an academic culture and a structured space around schools to interact and engage with teachers and children and creating linkages for dialogue between higher learning centres and school education.

3. Establishing a platform that foster linkages between various stakeholders of school education

It is important to develop mechanisms, systems and procedures within a university system that will bring together multiple stakeholders of education to a common forum to support school education. One of the ways to achieve this is establishing school resource centres, with supported libraries, at university centres. This will also be a space that coordinates various activities for teachers and children, where teachers can come together to design teaching-learning materials, can access updates on research in education to inform their practices, share knowledge and experiences of classroom teaching and emerge as a community of practitioners. Such centres will design, exhibit and hold exemplary teaching-learning materials and expertise on curricular research. In addition to the above, one of the aims of this program is coordinating summer workshops, monthly programs and vacation internship programs for school children in research institutes with the help of PhD student volunteers to communicate and introduce children to the practices of knowledge creation and culture of research. Such programs for schools and children can be coordinated and conducted on a regular basis by the school resource centres.

4. Collaborative content creation

The proposed program envisages a group of likeminded researchers from different disciplines working together to innovate on the Indian school curriculum and pedagogy and guide children through authentic inquiry practices. The expected outcome of the pilot phase of this program is evolving content and framework for introducing GIS in school, guidelines for using software that teachers can innovate and use in their own classrooms, creating local databases of a region working along with children, and trial running the implementation of such a program in schools. This can be achieved through collaborative work and content creation by a team of disciplinary experts working with teachers and children. What is needed is a synergized and concerted effort with research centres pooling their resources and expertise for creating content that provides ample scope for the teacher to be creative and innovate on the basic framework that can be adapted to the specific needs of a local environment and school.

For SEAD community

5. A collaborative partnership across SEAD network is proposed in the following areas

a) Creating local, national and international partnership across SEAD to foster peer to peer research and collaboration to share and exchange best practices, knowledge; also building a shared understanding of what technology enabled teaching-learning means for different countries and regions.

b) Sharing of experiences of authentic inquiry based teaching-learning practices in schools and learning from exemplary programs aimed at engaging students with real data on research problems that are approached creatively and collaboratively.

c) To facilitate the sharing of experiences of successful technology-enabled and GIS-based teaching-learning practices that are already in place in the US and other countries, to learn and build on ways of implementation, resource development, etc. Taking examples from successful exercises in the use of GIS elsewhere in order to show Indian schools the impact of this method; also share experiences of teacher training and preparation methods in previously envisioned and implemented approaches.

d) Connecting higher secondary children across different regions and nations: Creating a virtual space for higher secondary school children to use media to communicate effectively and interact with their counterparts in other countries and regions to know each other, to share and learn from each other about their physical and social world, to solve problems in real time, to share databases/maps created by them and also share experiences of collecting and making them, work together on interesting projects, and to take learning beyond the boundaries of the classrooms and nations.

e) Supporting usage of FOSS based tools and open educational resources: Since software is the foundation for digital technologies-based learning, we believe in using and promoting Free and Open Source Software (FOSS) that will make use of GIS affordable for schools. Through SEAD we like to network with like-minded researchers and open-source communities, who use FOSS based tools in school projects, enrich, document, and maintain them; also form a forum to share and collaboratively create open educational resources.

f) Insights on collaboration: Learning from earlier collaborative experiences of networked learning communities. One of the important issues in the Indian context is how ready educators are to collaborate, develop partnerships and make effective use of technology. Teachers are traditionally been trained for the teaching learning practices that are confined within the limit of a school classroom. Linking the practice of teaching and learning in schools to a larger collaborative network is, therefore, a major challenge

g) Creating Information systems and databases: Networking with researchers who are a part of citizen science projects to learn and share experience of creating information systems and databases together with school children. This is a very recent initiative attempt in

India. Moreover there are numerous free online data repositories which provide data on topography (DEM), rainfall, temperature, vegetation, population, socio-economic details etc. which can be directly linked to GIS platform and can be explored for the purpose in school classrooms.

h) Device to measure weather data: One of the main areas of this project that does not have complete technology support is about setting up a model weather station (to measure rainfall, wind, temperature, humidity etc.) in a school and identify appropriate instruments that can be used by children at school level. The long term plan is to work with climatologists to gather information on the climate of a region with the help school children to create information systems on important climate variables. The difficulty faced on this front has to do with developing rain gauge and other instruments that can be interfaced to a computer and that can be handled by school children, to give accurate measurements. We seek support and insights from researchers working in this area towards innovating solutions and developing devices that are affordable for schools.

i) Working with Government agencies, sustainability, scalability and funds: For any project of this nature to succeed beyond the pilot stages and to extend it to large number of schools, it is important to formulate partnerships with Government agencies involved in school education. We seek insight towards defining a replicable, scalable, and sustainable GIS project model for school children. Finally, sustaining such an endeavor requires funds and budget allocations. We need to explore financial and support arrangements and hence seek suggestions into means for securing funds.

For private sector

6. Private partnerships

There are multiple stakeholders who share the responsibility of children's school education, including the private sector. It is important to facilitate a systematic cooperation between school systems and the private sector. One of the proposals towards this is encouraging the private sector companies to adopt schools as part of their corporate social responsibility not only to bring about infrastructure changes; but also supporting curricular improvement and intervention programs.

For Universities and Researchers

7. Fostering a climate of curricular research and innovation in India

Incorporating a program of innovative curricular and pedagogic interventions in Indian schools requires advancing avenues for educational research and empowering the role of teacher as a researcher and a guide to children in the classroom. What is needed is a curricular and pedagogic framework developed on the basis of research that equips the child to acquire meaningful understanding of disciplinary concepts, thinking and skills. The prerequisite for incorporating GIS, digital technologies and innovative pedagogic programs into Indian school education is

establishing the right kind of institutions, expertise and positions in university systems for conceptualizing, designing and implementing curricular projects in schools.

Currently we recognize a major gap in these areas and see our work as providing a beginning towards this.

Acknowledgements

References

Bransford, John. D., Ann L. Brown and Rodney R.Cocking (eds.). How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press, 1999

Brown, Seely, J., Collins, Allan and Duguid, Paul. "Situated Cognition and the Culture of Learning." Educational Researcher 18 (1) 1989:32-42.

Bruner, Jerome S. The Process of Education. Cambridge, MA: Harvard University Press, 1977

Bruner, Jerome S. Towards a Theory of Instruction. Massachusetts: Harvard University Press, 1966.

Chinn, Clark A., and Betina A. Malhotra. "Epistemologically Authentic Inquiry in Schools: A Theoretical Framework for Evaluating Inquiry Tasks." Science Education 86 (2002):175-218

Clarke, Prema. Teaching and Learning: The Culture of Pedagogy. New Delhi: Sage Publications, 2001

Demirci,Ali. "Evaluating the Implementation and Effectiveness of GIS-Based Application in Secondary School Geography Lessons."American Journal of Applied Sciences 5 (3) 2008: 169-178.

Gardner, Howard and Boix V. Mansilla. Teaching for Understanding in the Disciplines – and Beyond, in Leach, Jenny and Moon, Bob (eds.), Learners and Pedagogy. Pp 78-88. Thousand Oaks: Sage Publications, 1999.

Hagevik, Rita A. "Five Steps to Success: Implementing Geospatial Technologies in the Science Classroom." Journal of Curriculum and Instruction 5 (1) 2011: 34-53

Incekara, Suleyman. "The Place of Geographic Information Systems (GIS) in the New Geography Curriculum of Turkey and Relevant Textbooks: Is GIS Contributing to the Geography Education in Secondary Schools?" Scientific Research and Essays 5(6) 2010: 551-559

Kerski, Joseph. J. "The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education." Journal of Geography 102 (2003): 128-137

Krajcik, Joe, Blumengeld, Phyllis, Marx, Ron, and Soloway, Elliot. "A Collaborative Model for Helping Middle Grade Teachers Learn Project-Based Instruction." The Elementary School Journal 94(5) 1994: 483–498.

Kuhn, Deanna, Black, John, Keselman, Alla, Kaplan, Danielle. "The Development of Cognitive Skills to Support Inquiry Learning." Cognition and Instruction 18 (4) 2000: 495-523

Kumar, Krishna. Political Agenda of Education: A Study of Colonialist and Nationalist Ideas. New Delhi: Sage Publications, 1991

Kumar, Krishna. What is Worth Teaching? New Delhi: Orient Longman,1997

Latour, Bruner and Woolgar, Steve. Laboratory life: The Social Construction of Scientific Facts. London: Sage, 1979

Lave, Jean and Wenger, Etienne. Situated Learning: Legitimate Peripheral Participation. Cambridge: Cambridge University Press, 1991

Lemberg, David and Stoltman, P. Joseph. "Geography Teaching and the New Technologies: Opportunities and Challenges." Journal of Education 181(3) 2001: 63–76.

Ministry of Human Resource Development (MHRD). National Policy on Information and Communication Technology (ICT) in School Education. NewDelhi: Department of School Education and Literacy, Ministry of Human Resource Development, Government of India,2010

National Council of Educational Research and Training (NCERT). National Curriculum Framework-2005 (NCF-2005). New Delhi: NCERT, 2005

Roth, Wolff-Michael and Lucas, B. Keith, "From "Truth" to "Invented reality": A Discourse Analysis of High School Physics Students' Talk about Scientific Knowledge." Journal of Research in Science Teaching, 34(2) 1997:145–179.

Roth, Wolff-Michael and Roychoudhury, Anita. "The Development of Science Process Skills in Authentic Contexts." Journal of Research in Science Teaching 30(2) 1993: 127–152.

Sarangapani, Padma. Constructing school knowledge. New Delhi: Sage Publications, 2003.

Schauble, Leona. "The Development of Scientific Reasoning in Knowledge-rich Contexts." Developmental Psychology 32(1996):102-119.

Schwartz, Rene S., Lederman, G. Norman and Barbara, A. Crawford. "Developing Views of Nature of Science in an Authentic Context: An Explicit Approach to Bridging the Gap between Nature of Science and Scientific Inquiry." Science Education 88 (2004):610–645.

Wanner, Steve and Kerski, Joseph. "The Effectiveness of GIS in High School Education." Proceedings of the ESRI User Conference, 1999.

Wood, David. Aspects of Teaching and Learning, in Richards, Martin and Light Paul (eds.), Children of Social Worlds: Development in a Social Context. pp 191-212. Cambridge: Harvard University Press, 1979.

Zimmerman, Corinne. "The Development of Scientific Reasoning Skills." Developmental Review 20(2000): 99-149.

Hackteria.Org: Nomadic Science and Democratized Labs

http://wp.me/P2oVig-kk

Coordinator: Denisa Kera and Marc Dusseiller (Hackteria.org)

Hackteria.org (Open Source Biological Art) initiative is an informal, open and experimental network supporting DIY (Do-It-Yourself) and open science practices across variety of contexts (artistic, academic, non-profit) and continents (EU, Asia, USA). Because of our emphasis on hybrid and experimental practices, which are often open ended, we do not use consensus as a necessary pre-requisite for action, but we emphasise documentation as a tool of reflection and deliberation, which help us evaluate our activities. The views discussed in this white paper do not represent the whole group, but our personal experiences with the workshops and events we organized over the years. We perceive the collaboration between science, engineering, arts and design for us as serving one main function: it increases and tests new models of public participation and engagement in science and technology and introduces a greater reflexiveness in the whole R&D and appropriation processes. Instead of communicating and disseminating results, on which scientists and policy makers eventually agree, we are interested in an experimental approach for policy deliberation, where all parties have an active role in the whole R&D process and where science is probed against many other fields and interests – social, aesthetic, political, philosophical, even culinary. It is our goal to simply bring closer science and all the facets of society by testing alternative and reflexive forms of R&D, which connect communities to prototype development and testing, and by negotiating variety of needs, fears, and hopes of different actors. We hope to bridge not only the divide between science and art but also between experts and amateurs and also citizens from different parts of the world by simply making scientific experiments accessible and by enabling research in developing countries (mainly India and Indonesia).
Based on our personal experiences with the Hackteria network, we have following suggestions:

Suggested Action 1.
Support open science and citizen science initiatives, such as co-working spaces and community labs as well as novel forms of public engagement in science and technology through workshops involving scientists, designers, artists and any other profession.

Barrier: The unclear status of many community labs and initiatives and the perceived tension between grassroots (independent and free) activity and institutionalized and monitored spaces.

Target (stakeholders): Grant agencies, Applied Research Funders, City councils, University management

Solution: Create a board of advisors representing different stakeholders (citizens, communities, faculty and professional researchers, galleries and artist collectives, grant bodies, city councils), which will take care of the economic, legal and other issues related to the management of such open space supporting interdisciplinary and inter-actors collaboration (Fablab, Citizen science, DIYbio lab or Hackerspace).

Suggested Action: Grant agencies can support cooperation between universities and existing informal, grassroots R&D centres (community labs, Hackerspaces) by dedicating part of the budget to support the infrastructure and the workshops in citizen science labs as a form of "dissemination of research results". Universities could support their faculty in volunteering in the citizen science labs teaching local communities various protocols and supporting citizen science initiatives and workshops. City councils could provide spaces and support related to legal and other issues, which the use of public space in citizen science projects brings (for example when installing sensors), but also in making such initiatives more visible in the public space and connecting them with other publically funded actors (galleries, museums, public libraries). General support of decentralized, open science and open access paradigms.

Suggested Action 2.

Support grassroots innovation and participatory design related to local communities when facing various local and global challenges.

Barrier: Interdisciplinary activities in the Hackerspaces, Fablabs and citizen labs are often perceived as something geeky, not really useful and without any impact.

Target (stakeholders): Local businesses, Employers, Government agencies, City councils Solution: The support of cooperation between research and commercial organisations should also involve the alternative R&D centres and support participatory design strategies in finding solution and developing socially and environmentally sensitive, grassroots innovation.

Suggested Action: We need to enable innovation and research outside the academia and industry walls by involving new actors often described as makers, tinkerers, and hackers, but also Do-It-Yourself (DIY) or Do-It-With-Others (DIWO) research subcultures. One simple way of doing this is to provide access and formulate calls, contracts and bids, job opportunities, which are suited for these alternative R&D spaces: projects supporting resilience, disaster management, or some form of civic engagement in ecological issues, "smart cities" projects, or when deliberation on ethical issues related to some emergent technology is needed. Citizen and alternative R&D labs can literally serve as incubation centres for local communities, where prototype testing goes hand in hand with deliberation and gathering of user feedback and requirements from variety of actors. We need to create opportunities for decentralized and nonlinear value chains and interactions between research, design (innovation), and policy.

Suggested Action 3.

Support research in developing countries, bridging science and technology divides, and formulating more inclusive and interdisciplinary research agenda based on global networks around low tech and DIY protocols and tools.

Barrier: Missing infrastructure, difficult access to information, stereotypes of where research and science is happening.

Target (stakeholders): UNESCO, intra-government institutions, non-profit organizations
Solution: Support exchanges between scientists, artists and designers across the world, connecting them with various local communities in developing countries (for example a network for graduate students visiting developing countries to teach short workshops or help local researchers in developing countries. Supporting open source hardware, open data, and open access platforms and approaches.

Suggested Action:
The open source model supports interdisciplinary cooperation across disciplines, but also continents and it creates an alternative network of knowledge transfer, which benefits various communities. We need to bridge the divide in science equipment and access to scientific publications and knowledge and to enable cooperation by supporting exchanges but also work on open source hardware tools and open access. We see research in developing countries as more embedded in the local communities and more engaged with the needs of concrete people rather than large scale stakeholders and actors. In this respect the agenda behind the research in developing countries in similar to citizen labs in any other country and there is a natural synergy. Support a network of science graduates and amateur scientists, who travel, share, and exchange knowledge with their peers and science enthusiasts in universities and labs across developing countries. Support science and art ambassadors who use low tech solutions and citizen science kits to build ad hoc lab techniques and equipment in order to teach and share science protocols with various communities around the world. By connecting communities and labs, oral and indigenous knowledge with scientific know-how, we hope to achieve a disruptive knowledge transfer between various cultures and create infrastructure for a truly global research efforts, which will tackle various issues more creatively but also efficiently.

Artistic Research Collaboratives in Science, Engineering and Technology (ARCiSET)

http://wp.me/P2oVig-nQ

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Introduction

Artistic Research Collaboratives in Science, Engineering and Technology, ARCiSET is an international sci-art research and action project designed to bring local, national and international communities together for the purposes of learning from each other. ARCiSET on Water: Cochin will bring together participants from India, the United States, Hong Kong, and Indonesia to investigate the links between arts practices, science, technology, cultural diplomacy, and water as a material resource and carrier of symbolic value, particularly within the context of rivers. Subsequently, the participants will return to their respective locales, and, in small teams, develop follow up projects that disseminate the processes and the work of the project in order to localize it further. This project will generate internationalization for and between the respective partners that can also lead to new university and community sci-arts initiatives.

In an effort to collaborate on how to generate new forms of communication, arts, design and technology across communities in Cochin who are struggling with these water issues and to create a model for generating best practices in the field of arts diplomacy this project --ARCiSET on Water: Cochin-- will partner with local agencies in science, engineering, law, and the arts to explore how we can use arts and design processes as methods of thematic inquiry and problem-solving in a cross-cultural context:

a) To catalyze new forms of cultural diversity and cultural diplomacy that prepares artists and their local communities to engage in global citizenship, with a specific focus on India, particularly in a trans-Pacific context, and

b) To create a model for generating best practices regarding university and community sci-arts initiatives in the context of the global university.

New methods of discourse and opportunities for artists across our local and global communities to engage in the conversation over water, and specifically in India, are more important than ever. These methods will allow communities to: 1) tell their local and global stories about water; 2) generate new social, political, and cultural dynamics around water practices; and, 3) find ways to bridge the science, art and religion divide that, unmitigated, haunts our water problems and limits our capacities to find new solutions fast enough.

In assessing the current phase of development of ARCiSET and the challenges I currently face as well as the opportunities these types of projects promise, my key recommendations include the following:

1. A set of think tanks, or cross-disciplinary research laboratories, housed in a range of US academic institutions that focus on the development of science-art research in the context of international collaborations across geographical sites. (The more ideal approach would be to create the think tanks as an international partnership between 2-3 institutions of higher education.)

   The primary relevant stakeholders are university administrators (with related community partners) with a vested interest in new program and curricular development that can take the arts and sciences to its next stage.

   The obstacle is the lack of both understanding of the potential and the buy-in for investing in new directions in the science-arts in terms of university-community collaborations in an international context.

   The second obstacle is the lack of a language or vocabulary and related set of practices that works across locations.

   Co-development of new science-art research can lead to the building of common cause around this type of work.

2. The advocacy for new funding opportunities with the NSF and various Foundations already committed to interdisciplinary work in the sciences, engineering, and technology but with, currently underserved focus on the role that the arts and culture can play in finding new solutions to the problems that currently face us in a global context.

   The relevant stakeholders are the funders as they gain new information about what can be done with their available funds in ways that reaches a larger population.

   The obstacle is lack of innovation in funding opportunities.

Thinking with Things: Feeling Your Way into STEM

Art and Science: Reclaiming the commonalities

The idea that art and science are at opposite ends of a spectrum of human endeavor is a relatively recent one. Throughout most of human history, and still today in many cultures, art has been far more deeply embedded in day to day activity and world view. In recent centuries, and only in advanced industrial societies, has art come to be synonymous with the fine arts—a boundary which has become a wall. It may help us to see the large areas of commonality between art and science if we remind ourselves that what we now call art was techne—a term which distinguished the human-made from the naturally occurring— to the ancient Greeks, and that this sense of art lasted even into the twentieth century in the US in expressions such as useful arts, which referred to fields such as engineering.

Art and science also have common roots developmentally. A child's exploration of the world is sensory, experimental, concrete, and embodied. The first Kindergarten materials, created by German educator Friedrich Froebel, drew on his background as a scientist, and particularly on his study of crystal structures. That Froebel's unit blocks, paper weaving, and "pea-and-toothpick" sets had a profound impact on artists and architects of the 20th century has been elegantly documented. Less well known is the impact on 20th century science, although a strong circumstantial case can be made. Richard Feynman's mother was a trained Froebel Kindergarten teacher who surely used the materials at home with her first-born; Richard's father declared his desire that his son be a scientist. Feynman's famously visual approach to problem solving, his diagrams, and his declaration that "mathematics is pattern" make particular sense for a scholar whose early learning made use of the new, tactile, manipulative and geometric approach to children's learning. Asking whether these early learning materials are art or science materials makes no sense—they are the wellspring of both.

In our endeavor to bring art and science back into close connection, the work of educator and philosopher John Dewey helps to point the way. Dewey famously stressed the centrality of experience in learning, and the activity of inquiry as the driver of learning. Dewey also rejected many commonly held dualisms, such as the Cartesian mind/body dualism, preferring instead to speak about the body-mind; this term was his way of uniting two things that, like art and science, had become separated. Recent research in neuroscience confirms Dewey's conviction that learning and cognition are embodied—that is, that the body and the brain are an inseparable system, a body-mind, that learns and acts in and with its environment.

Things to Think With: An Example

Inquiry is an activity that both art and science have in common. Scientists and artists may explore the properties of materials; may interrogate and critique concepts; may ask how past accomplishments affect their future work. Dewey's inquiry is active, embodied, rational, aesthetic. It is also interactive. Inquiry requires that we have things to inquire about. It is to this subject that I want to turn, using the odd but instructive example of crocheted hyperbolic planes.

A hyperbolic plane is a mathematical object, and a crocheted hyperbolic plane is a yarn model of that object, made with some simple crocheting. In formal terms, a hyperbolic plane is a surface of constant negative curvature—sort of the opposite of a sphere, which is a surface of constant positive curvature. If you find it hard to imagine, so did many mathematicians; until the 19th century, a hyperbolic plane was thought to be an impossible object. The first crocheted hyperbolic plane was made by computer scientist and mathematician Daina Taimiņa, using the skills she had been taught as a girl growing up in Latvia.

My own relationship to math was one of misery and torment, from grade school all the way through graduate school. When I first heard the phrase "crocheted hyperbolic plane" and realized that there were people who were making mathematical models with yarn I was shocked and intrigued. In my own mathematics education there had been no hint that such a conjunction would be conceivable. Thus began my own inquiry into math and other topics, launched by the crocheted hyperbolic plane.

(See also the web site I created, at http://www.thinkingwiththings.com/)

Here are some of the topics that I have encountered in the course of my inquiry:

Algorithms and representations

A crocheted hyperbolic plane is made by starting in the center and working outward in a spiral path, repeating the same crochet stitch hundreds of times. The instructions are an algorithm, not a formula; they are of the form "make X stitches, then make two stitches in the same location." The maker can decide what X is and then follow the procedure, receiving in the process a simple introduction to algorithms and variables. A crochet pattern and a Java program would represent these same instructions in very different ways. What is the clearest way of representing this algorithm, and for what audience?

Emergence

As you make a hyperbolic plane, its shape changes in unexpected ways. It may start as a bump or a flat disc, depending on the rate of increase and the bulkiness of the yarn. As you continue, the edges of the disc begin to buckle, then form the ruffled pattern of the finished product. Making a crocheted hyperbolic plane is a simple, tangible illustration of the systems principle of emergence, in which simple elements repeated form a whole that is quite unlike the individual elements.

Pattern and rhythm

Repetition in the making of a crocheted plane has pattern and a rhythm. Visually, the finished plane also has these properties. What did Feynman mean when he said "mathematics is pattern?" Does the crocheted plane shed any light on this?

Models

When making a hyperbolic plane, if you continue past the point where the ruffles are gentle curves, they become more acute and more tightly packed, and ultimately the crocheted hyperbolic plane approaches a sphere as its limit. The ideal, mathematical plane hyperbolic plane has no limit. Nor does it have thickness, or a spiral pattern. In what ways can a model both be, and not be, the thing it models? How might we be informed, or led astray, by using a model? How do the materials we choose (bulky vs. thin yarn, for example) affect how the model performs?

Engagement

Crocheted hyperbolic planes are engaging, even for those who say they "hate math." I have spent hours discussing math and math education with everyone from mathematicians to math phobics since I began making and handing around these models. They draw people in and spark inquiry; they can also help people to "get a grip" on math concepts.

Beauty

Crocheted hyperbolic planes are beautiful. For people like me who never understood what "the beauty of mathematics" could possibly refer to, it's a revelation. Yes, the beauty comes from the color, the sheen of the yarn, and other qualities, but it also comes from the elegant mathematical characteristics of which it is a model.

Gender

In American culture, math is associated with males, and crochet with females. Even though women and girls have made great strides in math performance in school, there is still a stereotype about girls and math that suggests that girls are less capable. Crocheted hyperbolic planes are provocative because they unite advanced mathematics with something associated with the feminine. In pilot research at the University of Massachusetts Lowell, we have found that women who hold a crocheted hyperbolic plane while listening to a math lecture and taking a test are more likely to report that they like math and would take more math courses, and are less likely to report math anxiety.

Emotion

As Sherry Turkle rightly observes, objects can be evocative. We have all had the experience of emotional responses to objects, and research shows us that emotion and learning are closely linked. Indeed, one of the implications of the recognition that cognition is embodied is that thinking and learning also have an emotional component. Evocative objects elicit emotion and provoke more sustained inquiry.

ArtScience
Are crocheted hyperbolic planes art, or are they STEM? The answer is yes.

Of course many objects can provoke inquiry. Examples from other SEAD White Papers include the Siler and Ozin Periodic Table of Nanomaterials and Tatar's discussion of sewed circuits. The list of possibilities is endless, although some objects and materials are more conducive than others to productive and sustained inquiry.

There is a stumbling block for those of us who believe in embodied cognition and that the body-mind should have evocative objects and environments with which to inquire. It is the prevailing belief, inherited from many sources including the Enlightenment and psychologist Jean Piaget, that adult learners are abstract thinkers and therefore do not need or benefit from "the concrete." In fact, as Piaget himself acknowledged, novice learners of any age can benefit from starting with physical materials and representations, interaction with which can scaffold more abstract thinking. The history of the STEM fields is full of examples where discoveries were sparked by objects and images, not just "abstract reasoning." STEM learners, like learners in the arts, benefit from interaction with materials.

Suggested Actions

For Faculty and Higher Education

#1 Select and create "Things to Think With"

Barrier: In most fields there is no classroom culture of inquiry with objects. "Concrete" thinking is stigmatized because college is supposed to be about ideas and "the life of the mind."

Action: Create great, field-specific examples of object-based inquiry in the classroom. Through research and practice, develop a counter-narrative that demonstrates the benefits to students.

#2 Create on-campus spaces that are ecosystems for learning

Barrier: Most college classrooms are barren spaces, often with only whiteboards, chairs, and computer technology. Faculty move from classroom to classroom and may therefore have a hard time customizing a room.

Action: Create resource-rich lab/studios for learning, perhaps tailored to the needs of a particular discipline or disciplines. At a minimum, equip each classroom with a cabinet so that physical materials can be stored and easily retrieved by faculty.

#3 Create excellent professional development experiences for faculty

Barrier: Faculty generally teach as they were taught.

Action: Create PD experiences that are offer new and revelatory learning experiences organized around engaged and inquiry-driven interaction with objects. Support the development of new curriculum.

#4 Do careful research and evaluation of the learning effects of thinking with things

Barrier: We infrequently evaluate teaching methods and effectiveness, or do research on what works in college.

Action: Create a culture of research and evaluation, of metacognitive discussion of teaching and learning, through on campus teaching centers, classroom assessment, and funding paired with technical support that allows more research and evaluation to take place.

For K-12 Schools and Teachers

#5 Support "arts integration" in academic subjects

Barrier: The arts are being driven out of K-12 by the stress on academic subjects. Students who do not respond well to current teaching methods are discouraged from pursuing STEM.

Action: Leveraging embodied knowing by using aesthetically informed pedagogy can improve learning of STEM subject matter and include more underrepresented students in STEM engagement.

#6 Create great curriculum for integrating arts inquiry

Barrier: Teachers do not have the time to develop whole new curricula and approaches.

Action: Develop curricula and exemplars of inquiry with objects to guide and inspire teachers.

#7 Support teacher professional development, planning, and collaboration

Barrier: Teachers do not know how to integrate the arts with STEM and other subjects.

Action: Provide engaging and effective professional development opportunities for teachers. "Sound Thinking" workshops are one example.
http://teaching.cs.uml.edu/~heines/TUES/WorkshopInformation.jsp

For Informal Educators

#8 Create "labs" in art institutions and "studios" in science centers

Barrier: Narrow view of the institution's mission; lack of financial resources for space creation and staffing.

Action: Develop a list of precedents and create a community of practice for informal ArtScience learning.

#9 Create and support "Maker Spaces"

Barrier: Informal STEM education is sometimes quite structured and "hands off." Makers lack resources to create their own spaces.
Action: Maker spaces support self-directed and synthetic interaction with materials, STEM content, and the arts. Promote the creation of maker spaces, a culture of tinkering and STEM inquiry, and validation of the sorts of learning that takes place in such spaces.

#10 Workshops to reduce math anxiety in teachers, parents, and students

Barrier: Math anxiety is pervasive in the US. Teachers with math anxiety may create anxiety in their students.

Action: Workshops that use hyperbolic crochet, fiber arts, creative craft, and other engaging and non-threatening activities can open an effective and supportive pathway into math learning.

For Funders, and State and National Policymakers

#11 Legitimize object-based learning and Maker Spaces by creating funding programs in this area

Barrier: In many fields, a Thinking With Things approach to learning is unusual and therefore hard to find funding for.

Action: Create solicitations that explicitly validate and offer to fund concrete, object-based approaches.

#12 Enforce best practices in program evaluation, and provide funding and technical assistance to grantees so they can achieve excellence in evaluation research

Barrier: Many experiments in new learning approaches are not well studied, which makes dissemination and improvement difficult.

Action: Fund and require excellent education research and assessment. Provide technical assistance so that investigators inexperienced in education research can be successful, or develop a funder-specific evaluation team to conduct the research.

References

Brosterman, N. (1997) Inventing Kindergarten. New York: Harry N. Abrams, Inc.
Cheit, E. (1975) The Useful Arts and the Liberal Tradition. The Carnegie Commission on Higher Education. McGraw-Hill.
Damasio, A. (1999) The Feeling of What Happens. Harcourt, Inc.
Johnson, M. (2007) The Meaning of the Body. University of Chicago Press.
Pasztory, E. (2005) Thinking With Things: Toward a New Vision of Art. University of Texas Press.
Piaget, J. (1972) "Intellectual Evolution from Adolescence to Adulthood." Human Develop. 15: 1-12.
Taimina, D. (2009) Crocheting Adventures with Hyperbolic Planes. Natick, MA: A K Peters, Ltd.
Turkle, S. (Ed.), (2011) Evocative Objects. MIT Press.

How I Became an Art[Scient]ist: A Tale of Paradisciplinarity

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Abstract – In 1992, I earned a PhD in evolutionary biology. In 2012, I obtained a PhD in dance. In the process of becoming an art[scient]ist, I have encountered many pitfalls and roadblocks, but also greatly benefited from remarkable opportunities. In this paper, I reflect on my own experience to present an insider's view of artscience, the rare tale of a scientist venturing in the field of art. I propose a roadmap for achieving paradisciplinarity; the parallel and symmetric practice of scientific and artistic activities. Namely, I present a list of sufficient and necessary conditions for the making of a true paradisciplinary art[scient]ist. This paper is not about collaborative artscience projects involving scientists and artists working on a common subject/object, it precisely concerns individuals who want to become successful art[scient]ists with dual careers, both as working scientists and performance/exhibiting artists.

Introduction

The literature on artscience (including SEAD white papers) is filled with examples of collaborations among scientists and artists working towards a common objective. Success stories abound to demonstrate the power of transdisciplinary projects, and to promote interactions between disciplines in the arts, the sciences and the humanities. In the field of bioart alone, several books are presenting and discussing the tools of the trade – the conditions for a successful integration of art and biotechnology (Hauser, 2003; Anker & Nelkin, 2004; Bulatov, 2004; Poissant & Daubner, 2005; Kac, 2007; Pandilovski, 2008; Reichle, 2009; Poissant & Daubner, 2012). Based on the shear number of publications on the subject, it looks easy to make bioart. Yet, the vast majority of bioartists have no formal training in cell and molecular biology, genetics, or genomics. If artists have a genuine desire to make art with the tools of science, they must be willing to collaborate with researchers in the field. The first risk of such artscience projects is for the artists to think that they are doing science when they are participating in the process of science (Bunt, 2008). The second risk of this interaction is to use the biologist as a technician, with no formal recognition of the scientific contribution to the creative process. This paper proposes one solution to this collaborative dilemma – paradisciplinarity. I am not concerned here with interdisciplinary projects involving several persons (scientists, engineers, artists, designers). I want to provide recommendations for training single individuals as artists and scientists. Based on my own experience as a bioartist with two PhDs, in biology and dance, I believe to be qualified to present an insider's view of paradisciplinarity.

Paradisciplinarity: what's in a word?

Unlike inter-, multi-, cross- and transdisciplinary collaborations, which define various types of interactions among a group of (at least two) individuals working together on a common project (e.g. an artist and a scientist), paradisciplinarity applies to a single individual practicing two disciplines at the same time.

Two conditions are thus required for any given practice to be defined as paradisciplinary:

i) Parallelism – the two disciplines must be performed in parallel by the same individual, in a synchronous fashion (a neurobiologist who is also choreographer clearly meets this criterion; a choreographer who changed career to become a neurobiologist does not)

ii) Symmetry – the importance (involvement) of each disciplinary practice must be relatively symmetrical in the individual's curriculum (a composer who publishes scientific papers in acoustics and also performs musical pieces in concert halls meets this second criterion; a physicist who publishes in scientific journal and also enjoys playing the piano at home does not)

Artscience provides a specific type of paradisciplinary research and creation. Strictly speaking, an art[scient]ist is an artist and a scientist at the same time. It corresponds to what Roger Malina (2010) defines as Type IV in his typology of artscience collaborations: individuals with dual careers both as working scientists and exhibiting artists (i.e. the classic/romantic model of the individual genius).

How to become an art[scient]ist?

The secret of artscience is in the making. The becoming of an art[scient]ist thus requires both formal training in scientific methods and artistic practices The process is painstaking, a difficult path paved with many pitfalls (too numerous to be listed here). It took me ten years to become an art[scient]ist. Or so I think. The paradisciplinary training of an individual in the arts and the sciences is just the first step. The true becoming of an art[scient]ist requires not only to master the technical tools and epistemological discourses of two trades at once, but ultimately to make significant contributions to both science and art. Short of this reciprocal relationship, one's contributions will remain that of an artist doing "trivial science", or that of a scientist making "trivial art" (Bunt 2008).

Assessing whether any given artscience practice is truly paradisciplinary relies on relevant metrics. When scientific and artistic contributions are analyzed separately, standard performance indices can be used (e.g., scientific papers, artworks, invited conferences, exhibitions, media coverage, grants, patents, etc.). The assessment of hybrid practices, however, may require new metrics to quantify the dual contributions of an art[scient]ist. Based on what factors should we measure the success of paradisciplinarity? Criteria of science, or criteria of art? Is the work having a lasting effect in the field or art, the field of science, or in both fields at once? How to compare the impact factor of a publication in Leonardo (or Nature) with the impact of a solo exhibition in a gallery (or MOMA)? Should qualitative measures be preferred over quantitative metrics?

How to become an art[scient]ist is an interesting question, but when to do it is even more important. Just as a child raised in two different languages will become fluent in both languages, a child exposed to science and art early on is more likely to understand and master the cultural differences of art and science. Yet, it's never too late to learn a foreign language. Which one should come first? Art or science? I was trained as a scientist before obtaining a second degree in

art, but the alternative path is also possible – and much more likely to be followed by bioartists. In practice, art[scient]ists rarely have a bicultural training and practice. Such a symmetrical and synchronous training is extremely unlikely. Which model should thus be promoted for training art[scient]ists? Art, then science? Science, then art? Art and science at once? It would be of great interest to assess the effects of various training scenarios using performance metrics from the fields of science and art.

The art[scient]ist as an experimenter

The modus operandi of artscience is to rely on a single creative process, artists and scientists being the "twin engines" of creativity working together towards the same goals (Wilson, 2010). Assuming that it is actually possible to participate in the research process in a similar way for both the artists and scientists, the question remains – how can a single person do it? As an art[scient]ist, I have encountered several roadblocks in my hybrid research, but I found one major commonality: experimentation is the meeting point of artscience practices. It is very important in the training of an art[scient]ist to enhance this experimental process and not just the product of the experiment (Edwards, 2010). In spite of cultural differences, experimentation is the antidote against the classical art/science dualism (see Snow, 1959). Claude Bernard (1865), the father of experimental medicine, defined scientific experimentation as "the art of obtaining rigorous and well-defined experiments". For the artist Allan Kaprow (1993), experimentation is "the verification or testing of a principle". One could easily swap these two definitions, which apply to both science and art. Experimentation represents the transversal dimension to any creative process, artistic of scientific. To become an art[scient]ist is, first and foremost, becoming an experimenter.

The art[scient]ist as a mediator

In theory, there is actually no difference in nature between experimental arts and sciences. The creative process, whatever it is, is part of the same quest – the act of experimenting, to make an experiment. The difficulty lies elsewhere, as to understand one another, artists must not only to master the experimental methodology of science, but the discourse of science (the opposite is also true for scientists venturing in artistic territories). For one, artists could study the scientific literature related to their areas of interest and develop a high level of skills and knowledge that enable them to become active practitioners in research. They would need at least to consider the scientific techniques of experimental design, which improve the clarity of the results (Wilson, 2005, p. 350). In parallel, the scientists would benefit from finding a way to be open to contributions from researchers from artistic disciplines. They would need to find a way to temporarily suspend the rigidity of their expectations regarding methodological protocols to accommodate non-traditional practices, results and technologies from other fields (Wilson, 2005, p. 351). When it will be possible for scientists to understand the work of artists without any prejudice and for artists in turn to appreciate the science at fair value, both areas will benefit from their epistemological differences. Nobody knows if science can progress without art, or if art can progress without science. Their mutual progress does not depend on their interaction, but the interaction governs the progress (Richmond, 1984). To establish a better interaction between researchers from arts and sciences, it is imperative for one to master the language of the other. In this particular context, the individual trained in paradisciplinarity plays a pivotal role; that of a

bicultural individual who can speak both languages. To become an art[scient]ist is becoming a mediator, a translator, an interpreter, an intercessor between two cultures.

Suggested actions

Given that (i) training an art[scient]ist is long-time process, (ii) that most art[scient]ist will have primary training in one field (art or science) followed by secondary training in the other field, and (iii) that different obstacles are impeding that secondary training and practice, I have established a list of sufficient and necessary (desirable) conditions for the making of an art[scient]ist. This (partial) list requires for any given bona fide art[scient]ist to: give scientific talks at arts conferences; show art/performance works at scientific conferences; obtain grants from scientific and art agencies; obtain joint faculty appointments in science and art departments; teach science to artists and art to scientists; supervise graduate projects in artscience; publish in art, science, and artscience journals. In order to meet these objectives, I have identified a number of actions, which could improve and encourage true paradisciplinarity in artscience practices, and promote the participation and involvement of art[scient]ists in academia, art institutions, funding agencies, etc.

LIST OF SUGGESTED ACTIONS

Suggested action # 1: Define novel metrics for artscience contributions

Barriers: The quantitative metrics of scientific research are quite different from the qualitative metric of artistic creativity.

Benefits: Develop objective measures of success for artscience projects (interdisciplinary or paradisciplinary).

Stakeholders: Funding agencies; University administrators.

Actions: Find similarities and differences in the metrics used by different funding agencies to determine the performance of scientists/artists. Develop hybrid measures that take into account significant contributions to both fields at once, not just the sum of scientific and artistic contributions taken separately. This may help funding agencies and university administrators making decisions in the evaluation of artscience projects.

Suggested action #2: Assess the relative performance of artscience curricula

Barriers: Impossible to compare different curricula, and assess when is the best time to learn artscience (high school level, undergraduate level, graduate level).

Benefits: Determine if it is best to learn how to do science before making art, how to make art before doing science, or learning both at the same time.
Stakeholders: University administrators.

Actions: Interdisciplinary curricula already focus on training individuals in the arts and the sciences. It is not clear that learning artscience in a simultaneous fashion is better than learning art and science (or science and art) in a successive (and cumulative) curriculum. Using the metrics defined in action #1, the relative success of art[scient]ists trained using different scenarios will be compared.

Suggested action #3: Advocate the role of mediators in artscience

Barriers: artistic mediators have no formal training in science; scientific mediators have no formal training in art.

Benefits: Create a new type of bicultural mediators for artscience practices.

Stakeholders: Funding agencies; Art institutions: Administrators; Artscience journals.
Actions: The paradisciplinary training of art[scient]ists will produce a new type of mediator for artscience projects. It is suggested to engage such intercessors in every project involving a group of artists and scientists working together. These mediators may also sit on search committees for joint artscience positions, on editorial boards of artscience journals, on the jury of artscience exhibitions, on review committees of funding agencies, as well as on the board of art institutions (galleries, museums).

Suggested action #4: Promote experimentation as a common tool for artscience practice

Barriers: artists have no (or little) experimental training in scientific methods; scientists have no experimental (or little) training in artistic practices.

Benefits: Enhance the knowledge of artscience experimentation in a large fraction of the population; improve the general public understanding of art and science.

Stakeholders: Instructors of art for scientists; Instructors of science for artists.

Actions: New courses should be added to science (respectively art) curricula to foster paradisciplinary training of art (respectively science). *I personally was interested in dance while taking a contemporary dance class for non-dancers; that lead me to doing a PhD in dance*. Science classes for non-scientists and art classes for non-artists should focus on the experimental process of making science and art, not only the theoretical aspects; that is, train artists to design and make scientific experiments; conversely, train scientist to experiment with some artistic media.

Suggested action #5: Create residence for scientists in art institutions

Barriers: Lack of funding sources; lack of interest.

Benefits: Better understanding of the art world by the scientists; better understanding of science by the art institutions.

Stakeholders: Art institutions; Art funding agencies.

Actions: There are quite a few programs already in place to host artists in scientific labs (e.g. Symbiotica), but fewer options are currently available for scientists. Funding agencies should create specific "scientist-in-residence" programs to promote artscience integration. Art institutions should be more open to hosting scientists for developing long-term relationships between art and science.

REFERENCES

Anker, S. & Nelkin, D. (2004). The molecular gaze: Art in the genetic age. New York: Cold Spring Harbor Laboratory Press.

Bernard, C. (1865). Introduction à l'étude de la médecine expérimentale. Paris: Garnier-Flammarion.

Bulatov, D. (2004). Biomediale: Contemporary society and genomic culture. Kaliningrad, Russia: The National Centre for Contemporary art.

Bunt, S. (2008). The role of the scientist and science in bio-art. Pages 62-67, in Art in the biotech era (M. Pandilovski, Ed.). Adelaide: Experimental Art Foundation.

Edwards, D. (2010). The lab: Creativity and culture. Cambridge, MA: Harvard University Press.

Hauser, J. (2003). L'Art biotech'. Trézélan: Éditions Filigranes.

Kac, E. (2007). Signs of life: Bio art and beyond. Cambridge, MA: MIT Press.

Kaprow, A. (1993). Essays on the blurring of art and life. Berkeley: University of California Press.

Malina, R. (2010). What are the different types of art-science collaboration. http://malina.diatrope.com/2010/08/29/what-are-the-different-types-of-art-science-collaboration/

Pandilovski, M. (2008). Art in the biotech era. Adelaide: Experimental Art Foundation.

Poissant, L. & Daubner, E. (2005). Art et biotechnologie. Québec: Presses de l'Université du Québec.

Poissant, L. and Daubner, E. (2012). Bioart: Transformations du vivant. Québec: Presses de l'Université du Québec.

Reichle, I. (2009). Art in the age of technoscience: Genetic engineering, robotics, and artificial life in contemporary art. New York: Springer.

Richmond, S. (1984). The interaction of art and science. Leonardo, 17: 81-86.

Snow, C. P. (1959). The two cultures. London: Cambridge University Press.

Wilson, S. (2005). La contribution potentielle des bioartistes à la recherche. Pages 335-352, in Art et biotechnologie (L. Poissant & E. Daubner, Eds.). Québec: Presses de l'Université du Québec.

Wilson, S. (2010). Art + science now. London: Thames et Hudson.

Interactions among Scientists/Engineers and Artists/Designers in Developing a Common Language and Unique Perspectives on Today's Challenges

ABSTRACT

The technical and societal challenges we face at the dawn of the 21st century will likely require not only the continued development of 20th century technologies, strategies, and educational approaches, but also more fundamental shifts in the way that we perceive and relate to our world. Artists/designers and scientists/engineers are uniquely positioned via their respective training and creativities to enhance our view of the world in different, but complementary, ways. A virtual symposium held in November 2011 brought together professionals from diverse fields working with the oceans or water, which is often considered today's most critical resource. Interactions and presentations highlighted opportunities and challenges, which included [1] developing a common language (verbal, visual, mathematical, auditory, etc.) for communicating across disciplines, [2] utilizing art or artistic portrayals to describe, investigate and preserve nature, [3] incorporating scientific perspectives into the creations of artists and designers who reach people in innovative ways, and [4] expanding the knowledge of and feeling for nature through diverse expressions. A subset of these opportunities and challenges is addressed in this paper.

INTRODUCTION

The interaction between science/engineering and art/design (SEAD) can extend far beyond the former providing novel technologies for latter or the latter providing clever ways to portray the former. Long-standing arguments as to whether artists can accurately portray the intricacies of scientific theories, which themselves are continually revised, or whether scientists can recognize the nuances and meanings of artistic works may not be the salient issues. Instead, the combined perspectives of artists and scientists that arise from fundamentally different ways of observing, interpreting, and describing the world may provide each other and all people with unique ways of viewing the natural world and approaching the challenges associated with it. Many significant breakthroughs in the arts, sciences, and design/engineering fields have resulted, not from the modification of standard or accepted views, but from fundamentally different ways of perceiving the world—whether through the senses or intellect. Artists/designers and scientists/engineers are uniquely positioned via their respective training, discoveries, and creativities to view the world in different and mutually beneficial ways.

Although art and science were closely linked during the time of Galileo and Leonardo, post-18th century trends have defined art, design, engineering, and science as separate professions (Kemp 2010). Distinguishing artistic images from rigorous mathematical descriptions of the natural world has resulted in less and less interaction among the two groups. In addition to an increasing

specialization among most scientists and an "art for the sake of art" philosophy among some artists during the postmodern era, both the jargon and tools employed by scientists and artists in performing and presenting their respective work seem to have become more distinct, arcane, and mutually irrelevant. There is recent optimism among art-science enthusiasts that the expanding realm of digital media, including the international open-source movement, could assist them in addressing the issue of separate tools (Wilson 2010). However, a shared computer literacy alone is unlikely to bridge the profession-specific jargon gap between scientists and artists.

COMMUNICATION MODES

Devising new words or altering/expanding the meaning of existing ones to somehow create a verbal or written language that is common to both artists and scientists would be difficult given the breadth of topics required to be addressed. In his book entitled The Artful Universe (1995), John Barrow examines the origins of our sense of beauty, order, and other aesthetics in light of the underlying spatial and temporal patterns of the physical world. In fact, we humans embody many of the same patterns (at least on a physical level) as those we perceive and appreciate (either consciously or unconsciously) in the world around us. Martin Kemp's book Seen/Unseen (2006) discusses in detail the ways in which major scientific theories throughout history have been influenced by visualization and the ability of scientists to both create visual models and to take inspiration from images they encounter. And vision is not the only sensory mode from which scientists have gained insight and inspiration for their theories. Auditory cues from both nature and music have also served as inspiration for scientific breakthroughs and for insightful perspectives on natural phenomena over a range of spatial and temporal scales.

Art has been described in terms of pattern and rhythm as a combination of elements repeated in a predictable and variable manner, respectively. Similarly, musicians use repeated elements that vary in their predictably and, thus, produce a balance of expected and unexpected elements for listeners who find the compositions aesthetically pleasing (Levitin et al. 2012). Although only certain branches of science specifically focus on patterns, rhythms, and repetition, data from a wide range of natural phenomena and scientific fields can be expressed in terms of vibrations, cycles, frequencies, and other descriptors of rhythm, as well as distributions, geometries, shapes, and similar descriptors of pattern (Ball 1999). Design and mathematical aspects of engineering are amenable to representation by patterns and rhythms, which are specifically integrated into the final systems and products. Generally regarded as the fundamental language of both science and engineering, mathematics is commonly linked to rhythmic sounds and movements that have been used to teach school children otherwise abstract subjects such as arithmetic (Alton 1998).

Is there something universal about the geometries, cycles, symmetry, balance, and repeated patterns in nature that artists and musicians incorporate into their works and compositions and that scientists and engineers reveal in their theories and complex mathematics? And what underlies the perception of beauty, perfection, or resonance in art and science? These are not just ethereal questions, but instead may point to factors that provide the impetus for the kinds of scientific and artistic breakthroughs that could allow us to more efficiently address today's challenges and to more effectively communicate the essence of those challenges to others. Whereas the answers to these questions remain a mystery, there are an astonishing number of physical, social, and related systems that can be described by fractal relationships, 1/f structures,

and hierarchical designs (Chen 2011). Fractals suggest underlying spatial and temporal patterns that often appear random or disordered at first glance, but are represented in everything from music and art to landscapes and heartbeats. Is our perception of beauty, whether inherent in a piece of music or a photograph of a glacier, related to an underlying fractal-like hierarchy that resonates to something within us and to everything around us?

When the topic of communication among professionals in different fields is raised, it is often assumed that words or numbers represent the best candidates for constructing or distilling a common language; but this may not be the case. It may be that pattern and rhythm represent better candidates simply because they are more universal. Whereas the existence of rhythm and pattern within disciplines as diverse as science, engineering, art, and design has been recognized for centuries, communicating about or presenting scientific and artistic works in a language that specifically facilitates interactions between artists and scientists is of more recent interest. The OpenLab at U.C. Santa Cruz is a good example of a research facility focused on communication between scientists and artists to the benefit of both (openlabresearch.com).

PATTERNS AND RHYTHMS

The idea that pattern or rhythm could, in and of itself, represent a form of communication or language among scientists, artists, and designers is certainly not a new one. The British architect Christopher Alexander (1977) wrote about a pattern language consisting of a hierarchy of parts, or design components, that are linked together by patterns capable of addressing and solving problems associated with each of its parts. The patterns themselves can be scaled up or down, creating what might be termed a fractal-like network and revealing information on higher hierarchical levels that is not present on lower ones. The patterns, which express the possible relationships among parts, consist of rules that work equally well for the natural and architectural (designed) worlds. It is the link among parts that permits the pattern to serve as a language.

Expanding on Alexander's ideas, Nikos Salingaros (2000) explains that pattern languages assist in addressing the complexity inherent in a wide range of natural and human-designed systems. He also describes how to develop and validate pattern languages for different systems so that they can adapt to or change our environment. This ability is particularly germane to the present discussion because pattern language is a way of connecting designs to human beings and, in turn, devising solutions. Although patterns are distinct from scientific theories in their being derived from observations, rather than from first principles, they do provide a basis from which scientific theories can emerge and most natural phenomena can be described (Salingaros 2000). Pattern language is directly applicable to wide variety of natural systems that are described by complex networks composed of individual components or nodes, which connect and disconnect to one another according to a set of rules, or laws, in determining a system's self-organizing behavior.

The theory that both chaos and geometric order are required to produce quality architectural designs, many of which unfold in an unpredictable manner, is based on the way that individual patterns are added during the design process (Rubinowicz 2000). By the same token, geometric and pattern languages have been devised for music, permitting both rhythm and pitch to be described as transformations of sets of points or nodes (Meredith 2012). Whereas music is often considered the realm of human artists, at least one researcher has hypothesized that non-human organisms use rhythm based communication, which relies on the synchronization of biological

rhythms among two organisms such that predictable time windows are established for sending and receiving signals (Beamish 2010).

The physical, chemical, and biological worlds are replete with examples of systems describable by patterns, rhythms, and fractal-like relationships evident on scales ranging from the atomic to the cosmic. Even scientific data that are not specifically presented in terms of patterns, rhythms or hierarchical relationships can often be perceived or interpreted in those terms or, at the very least, compared and contrasted with studies that do include such data (Marrin 2012).

APPLICATIONS

The following applications were drawn from a recent symposium that brought together scientists, engineers, artists, musicians, filmmakers, and designers (isaswr.com). The participants shared their work with water and the oceans, showcasing a variety of approaches and challenges to combining technical and artistic pursuits in an attempt to either bring awareness to or develop practical solutions for water-related challenges. Many of these pursuits capitalize on the patterns or rhythms that are common to both the arts and sciences.

Linking Nature to Human Emotion and Education. Filmmaker Carlos Mora captures water's rhythms, movements, and resulting patterns in natural settings and encourages a "culture of water" whereby artists, designers, scientists, and all interested people share their views and experiences. He has created an online forum that permits people to communicate about water using different modalities while adhering to common themes, thus facilitating a multimedia conversation from which common elements can be recognized and a link between seemingly dissimilar descriptions or perceptions of water can be made (somosagua.mx).

Using Art to Focus Attention on Environmental Challenges. Artist and professor Pamela Longobardi has spent time documenting and cleaning up plastic wastes that are carried by ocean currents to coastlines throughout the world. Her Drifters Project focuses on global-scale patterns created by the oceanic transport of plastics and smaller-scale patterns of plastic wastes that are distributed along beaches (driftersproject.net). One facet of her art involves the use of selected plastic wastes to produce installations and exhibits on an even smaller scale that symbolically focus attention on the destructive fabrication and use of plastics (Longobardi 2010). Possessing a scientific background, she approaches each new site as a forensic researcher.

Creating Functional Art across Spatial Scales. Artist and professor Mara Haseltine has created artificial reefs and other underwater habitats based on the geometry, patterning, and functionality of natural reefs and on scaling-up microscopic structures in nature to facilitate the reintroduction of marine organisms. In addition to the structure of her reefs, she has experimented with various materials (e.g., glass, metal, porcelain) in order to provide optimal substrates for the colonization of marine organisms (Haseltine 2013). Particularly interesting is her use of nature's microscopic structures and patterns to create macroscopic designs (calamara.com). Her artwork incorporates geometries and patterns that serve valuable scientific/engineering purposes and that unite cultural and biological evolution through a practice known as "geotherapy."

Integrating Art, Design, and Engineering. Landscape architect Greg Shinn has mediated among artists, engineers, designers, and regulators in conjunction with projects where artists are asked to explain, rather than to produce, their work under an unfamiliar set of guidelines. The challenge of translating the artist's intuitive vision into the engineer's practical work is one that requires a mediator who can express and understand visions in multiple languages, whether they are verbal, graphical, intuitive, mathematical, or otherwise. Emulating the methods of such translators is potentially valuable for facilitating communication among technical professionals and artists whose work must be integrated into multifaceted projects.

Choreographing Dance to Nature's Rhythm. Dance director Kimi Eisele choreographs various performances that experientially link audiences to local environmental issues, with the goal of changing the perceptions and behaviors of people through movement. Based upon the natural rhythm of water's movement and of humans' interacting with water, audiences are given the opportunity to perceive local water challenges differently. She connects human physicality and feeling to an awareness of environmental problems and solutions (NewARTiculations.org).

SUMMARY

In addition to the challenge of communication among scientists/engineers and artists/designers, style, culture, and value differences among the two groups have also been identified as potential hurdles to collaboration (Mitchell et al. 2003). Nonetheless, communication or language barriers may represent the most formidable of those mentioned and could inhibit SEAD collaborations that might otherwise yield new perspectives for addressing environmental challenges and more effectively relating those challenges to the public. The suggested actions in this white paper focus on increasing the potential for art-science collaborations by emphasizing elements that are common (and perhaps fundamental) to both and, at the same time, bypassing the esoteric words, descriptions, and symbols that often separate their respective cultures and styles.

SUGGESTED ACTIONS

Environmental Activist/Conservation Groups

[1] Approach the natural world (e.g., water, air, land) not only as problematic issues, but also as a model for solutions that can assist in balancing relationships among human interests. Messages incorporating an underlying pattern or rhythm that appeals to everyone are unifying, rather than divisive. Explore using the subtle messages of art or music, as well as the more overt messages of statistics and scientific predictions, in reaching a wider range of audiences.

[2] Organize environmental cleanups such that participants observe the spatial distribution and temporal appearance of debris as a means of interpreting where it may have originated, how and when it may have been transported, and how the environment has altered it. When appealing to audiences, experiment with ways in which pollution or ecosystem degradation can be identified with patterns or rhythms that are different from those of more pristine environments.

Educators and Educational Institutions

[3] Utilize the tools of rhythm and pattern to teach elementary and high school subjects such as mathematics and science, rendering these subjects less abstract to students. Devise college-level courses that emphasize underlying patterns, rhythms, and fractal-like relationships from both the science/engineering and art/design fields as a means of encouraging students to identify common themes or components and to express those commonalities as a balanced view of nature.

[4] Establish cross-disciplinary courses that examine and compare methodologies employed by artists and scientists in investigating, portraying, and experimenting with the natural world. Emphasize how the tools and intentions of scientists/engineers can assist artists/designers in their work, and vice-versa. An example of this type of cross-disciplinary course may be found at the website http//:gsuart.pbworks.com/w/page/7011421/FrontPage.

Professional Organizations and Organizers

[5] Arrange formal links among organizations representing SEAD professionals in order to plan joint meetings and to sponsor virtual or face-to-face forums where the focus is interdisciplinary communication and development of a common language leading to permanent relationships. Recognize that seemingly unrelated viewpoints on various topics, as well as understandings drawn from different fields, when communicated through a common language such as pattern and rhythm, can yield transformational insights or perceptual shifts in science, art, and design.

Government Planning/Regulatory Agencies

[6] Consult a range of professionals early in decision-making processes and consider the use of mediators who are conversant in the languages of SEAD participants, as well as regulations or planning requirements. Seek out professionals from relevant fields and institutions interested in forging a relationship between scientists/engineers and artists/designers. Suggest the use of pattern, rhythm, and hierarchical relationships as a way to enhance the communication among SEAD professionals and to demonstrate how understanding processes or devising solutions at one level of management may be scaled up or down to other levels.

Public and Private Funding Institutions

[7] Support projects that present or reanalyze scientific results and engineering specifications in terms of pattern, rhythm, fractal-like structures, hierarchies, or other common elements that can be more easily translated into or from artistic and design works. Add a funding category to support artists who produce designs that are based on their interpretation of natural structures or cycles and that are directly applicable to scientific or engineering projects in addressing real-world challenges. Support the expansion of media and technologies that foster communication among professionals via a common language and offer didactic perceptions of the natural world and our challenges with it.

REFERENCES

Alexander, Christopher, Sara Ishikawa & Murray Silverstein. A Pattern Language. Oxford, UK: Oxford University Press (1977).

Alton, Cris Marie. The rhythm of mathematics. Classroom Compass 4 (1998): 2.

Ball, Philip. The Self-Made Tapestry: Pattern formation in nature. Oxford, UK: Oxford University Press (1999).

Barrow, John D. The Artful Universe. New York, NY: Oxford University Press (1995).

Beamish, Peter. Conventional time versus rhythmic time. Journal of Consciousness Exploration & Research 1 (2010): 729.

Chen, Yanguang. Zipf's law, 1/f noise, and fractal hierarchy. Chaos, Solitons & Fractals 45 (2012): 63.

Haseltine, Mara. Sustainable reef design to optimize habitat restoration. In: Innovative Methods of Marine Ecosystem Restoration. Abingdon, UK: CRC Press (2013): in press.

Kemp, Martin. Art meets science: reuniting the severed cultures. New Scientist (11 May 2010).

Kemp, Martin. Seen/Unseen: Art, science, and intuition from Leonardo to the Hubble Telescope. Oxford, UK: Oxford University Press (2006).

Levitin, Daniel, Parag Chordia & Vinod Menon. Musical rhythm spectra from Bach to Joplin obey a 1/f power law. Proceedings of the National Academy of Sciences 109 (2012): 3716.

Longobardi, Pamela. Drifters: Plastics, pollution and personhood. Milan, Italy: Charta (2010).

Marrin, D.L. Water, fractals and watershed processes. In: Water Issues Related to Environmental Landscape Sustainability, Sousse, Tunisia: Sousse University Publication (2012): 161.

Meredith, David. A geometric language for representing structure in polyphonic music. In: Proceedings of the 13th International Society for Music Information Retrieval Conference (2012): 133.

Mitchell, W.J., A.S. Inouye & M.S. Blumenthal. Executive summary and recommendations. In: Beyond Productivity: Information, technology, innovation, and creativity. Washington DC: National Academy of Sciences (2003).

Rubinowicz, Pawel. Chaos and geometric order in architecture and design. Journal for Geometry and Graphics 4 (2000): 197.

Salingaros, Nikos. The structure of pattern languages. Architectural Research Quarterly 4 (2000): 149.

Wilson, Stephen. Art meets science: speaking a lingua digica. New Scientist (13 May 2010).

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Bio Structures and New Media: A Pending Prospective on Possible Futures Experienced in South America

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Abstract

Headings In developing a syncretic project of modernity, the particularities of the southern cone end variables to develop and materialize mainly utopian principles of an alternative modernity, have been built, in some way, and we have configured our ability, or inability place. In recent times, in the field of general projective disciplines (from visual information design to civil engineering, through architecture and urban), and the specific designers, the term has emerged: Bio Arch Digital. In a "prospective" vision, propose four keys to understand from our local developments, as we might have come to define this field since the end of World War II until the end of the cold war, to in turn be aware the new dynamics between Decentralized Collaborative Independence (ICD), and the relationship of art + science + technology + society, in a perspective that attempts to resolve some of our contradictions. To reach these conclusions for the future, it would be possible apply the following criteria from the viable system model: every organization is summarized in three elements (conceptual decision + technological media + environment) generated by joining one quarter turn, called the action.

Key Words: prospective, alternative modernity, bio architecture, South America, new media.

Prospective interfaces between art + science + technology + society, in, and from, the South Cone Pacific.

The cybernetician Stafford Beer explain Viable System Model (VSM) basis in three elements: a triangle between decision and control, technology and environment. Each "organizational system", make "the action" from this three basic points. Beer worked at an interdisciplinary experience about technology, organizational communication on line, and interdisciplinary collaboration; inside de Chilean government innovation politics between 1971 and 1973. [1] The project was named Cybersyn (Sinergic Cybernetic), or Synco Project. On this project Isaquino Benadof did a software named Cyberstride, the one who use a methodology similar Critical Path Method (CPM). This methodology came from engineering prospective, and means to do a past time line, and then modeling "possible futures."

If we look at the "past futures", after the world second war, the Chilean architectural students change his study plans under the "avant garde" statements. They did a kind of "Viable System Model": the *Integral Architecture* (Figure 1[i], Figure 2[ii]). [2] It means a designer study plan through three basic elements: human being + nature + shape. Two years process of "analysis", and then 3 years of "synthesis"(Figure 3 [iii]). The teamwork, the bio architecture study, and another similar

statement, did South American post war architecture under the organic urban organizational concepts. And then, like a response, the new Chilean engineering, with Abraham Freifeld, talked about a neo organic constructivist: contemporary experiences about theory of relativity, "ki" oriental energy concepts, and gestalt therapy interactional models. It a second integral-organic viable system model from this prospective. [3]

Parallel engineering experiences, seeking integration of human expression, with Carlos Martinoya group, did interdisciplinary models with cognitive visual perception, math, nuclear physic, and in the last sixties, with neurophysiology, theater, anthropology and sociology. In the late fifties, the engineer and physicist Juan Carlos Martinoya decides along the optical researcher Joel Nahum, build a system of visual projections strobe through birefringent crystals, with which viewers of the show of fine arts park forest in 1959, could interact. [4]

In the late sixties, a group of two psycho physiologists, Susana Bloch and Guy Santibañez, did research with the theater director Pedro Orthous on training techniques of actors. [5]

Santibáñez was one of the founding faculty of the School of Psychology at the University of Chile, and the first professor of psychology epistemology. Within a few years the Bloch, Santibáñez and Orthous group joins Martionya, and with Luis Strozzi an anthropologist and a sociologist Arístides Giavelli, plus visual artists Carlos Ortúzar and Virginia Hunneus, transform this epistemology class in a seminar on Art, Science and Technology (1971). In an interview at the time Carlos Martinoya question: "we have the technology, now what?" [6]

Heirs TONUS music group, engineers Juan Amenábar and Vicente Asuar were pioneers in the development of electronic music, also late fifties. They developed a laboratory of electro acoustic music in those years. Asuar and Amenabar studied at the Faculty of Music at the same time as the School of Engineering. In the seventies Asuar makes Sound Engineering School within the Faculty of Music, and in 1979 built a computer one of a kind, the Comdasuar to produce their work.

In 1968, following the model "Integral Architecture" somehow, began the Art and Technology Faculty, in University of Chile, Valparaiso. Then, in the early seventies, when some engineering use the new prospective software, like Hellmuth Stuven, they invent "cybernetic" interdisciplinary and organic uses.

And from the specific perspective of the concept of interaction, after HfG Ulm experience, Gui Bonsiepe directs Technologic Institute of Corfo Chile (1968 – 1973), beginning to talk about Interfaz (interface), and the "value of use" of aesthetic with three steps: 1º Trouble-structure, 2º Design, 3º Work make. [7] Then, ending the eighties Miguel Giacaman, did an anti virus, Vir- Det, with immunological bio model. In the era of knowledge economy and information technologies, the projection of these principles can thus at this time.

Until this day we can say that the greatest fact between art, science, technology and society, was the education reform that occurred in 1928 (figure 5[vi], Figure 6[vii]
Figure 7[viii]) according to a local interpretation of the ideas of "active school" or "new school." Despite its abrupt halt in 1929, however the complexity degree implemented then, in many ways,

determine what will happen thereafter. This reform was the result of a very important movement of teachers, in which the direction of changes in art education were directed by Carlos Isamitt.

Developing a short history about interdisciplinary interfaces between "Viable Systems Models", and organic and integrated systems, may be made a final prospective about interfaces and future models, from South Pacific Cone experiences to another context.

What´s prospective mean? Possible futures.

According to the Chilean working group Holon Lab framework (2007-2012), Maurice Yolles follow the Stafford Beer methodology. If we took the viable System Model like a start point, we could watch at some possible futures.

We could see the past, like possible futures, that´s the meaning of prospective methodology. Then, with a sociological symbolic production field it´s possible write lines about epistemologies, then interfaces, and finally social representational systems (or institutions). Influence International scope and participation opportunities.
The principal, and more complex line, is the epistemological line, where we could find the conceptualization process.

Each process of conceptualization or epistemological model is projected as a viable system model, but not always with success.

Viable system model is the result of a reconstruction of fragmented subject in terms of modernity linear specialties. Technology, from the perspective of cybernetics proposed Stafford Beer, also means to use interdisciplinary forms.

Therefore a viable system model, means that the conceptualization of a model of relationships between art, science, technology and society, undertakes a integral view of the environment in which it is expressed. Moreover, Yolles said that all organizational model could be reduced to three elements. This latest forecast may be methodological starting point when making a forecast (prospective).

Bioarchitecture. Human Being + Nature + Matter: Integral Architecture

After the Second World War (1945), students of architecture at the University of Chile generated more radical process of transformation of the curriculum, from references to the various trends of modern architecture, as well as movements previous reform. Suggesting a model that was developed from the basis of combinations of factors: man (human being) + nature (environment) + matter (and technology), to achieve through analysis and synthesis, the architect and the Integrated Architecture. [8]

Within this innovative architectural education revolution that was developing a collaborative network among young design schools: Tucuman, Buenos Aires, Montevideo, Mexico City, Lima

and Santiago de Chile, one of the most advanced was the implementation teaching of Bio Architecture, since the international congress of 1947, held in UNI Lima.

This instance was driven primarily by the surgeon Dr. José Gaciatello admirer of Le Corbusier's theories, and yet with a demonstrated social commitment. For one of the first times in the world, in teaching a school of architecture, this link was implemented systematic relationships between anatomy and urbanism, between biology and architecture for perceptual indissoluble relationships to the conception of the city felt and thought of as a living organism (Figure 8[ix]).

These principles produce a generation that wanted to develop a comprehensive modernity in, or from the extreme southern cone as utopian principles of their background between the recognition of the cultural characteristics of each place and the scientific and technological functionalism.

The first generations of graduates new curriculum, according to the principles of Integrated Architecture, raised themselves to solve the challenge of training and a continuous self-education that was able to "solve the problems of the development of Chile through the architecture " (Ehijo, Francisco: 2006).

So, then came graduation exceptional professional projects, such as the team of Ricardo Tapia, Victor Nazal, Carlos Albrecht, Carlos Martner, and Francisco Ehijo with unprecedented depth issues as "healthy populations of Santiago."

Moreover Team Ana Maria Barrenechea, Sergio Gonzalez and Miguel Lawner faced the problem of land reform from the perspective of the architects with research entitled "Background to rural planning."

Both works were focused on a common saying regarding interconnected and complex development of real variables that make up the architecture, and susceptibility present in almost all the projects that were presented at the time.

The thesis of former student leader Abraham Schapira, for example, said regarding the use of energy, "environmental issues solar".

Previously, these same ideas raised in the draft "University Centers" ("Núcleos Universitarios"), which was a critical counterpoint of students to the idea of "University City" ("Ciudad Universitaria"), isolated from the community and urban systems.

The structure of this new plan consisted of 06 blocks through 03 cycles:

- Philosophical block
- Sociological block
- Plastic Block
- Technical Block
- Supplementary materials block.

a) Analysis or preparatory cycle of 2 years.

b) Synthesis Cycle: Formative of 3 years.

c) Cycle Practice: Research and graduation: 1 year.

Exercise cycle was made up of seminars and Final Project, supported by 03 research departments:

-History
-Urbanism
- Construction and Stability.

Cycle analysis Reform Plan introduced new chairs in the emerging architectural education. The main ones were:

-Architectural Analysis
-Biology or Bio Architecture
- Social Economy.

In 2005, Beatriz Mella is investigating the course "Architectural Analysis", taught by a former member of the Bauhaus Tibor Weiner (1946-1947).

One of the students of that course, the architect Ricardo Tapia Chuaqui for this research reconstructs (2005) some of their notes and class schedules.

This work is one of the more specific evidence regarding which meant designing "the basic molecule of living" in the period immediately following the implementation of new teaching program (Figure 9[x]).

It is in this context that a team of three students, Pastor Correa, Jorge Martinez and Juan Honold, undertake a three-year project, which sat largely precedents what became the Regulatory Plan Intercommunal Santiago (PRIS), enacted in 1960 (Figure 10[xi]).

With the common conviction and integrated practical problems, ranging structuring an epistemological framework, which then verify a methodology that to this day remains an important local precedent in the history of planning from these ideas.

Epistemology of the city designed as a living organism

According to authors like Lev Manovich or Bureaud Annick[9], new media relate to the practices of mediation and interaction, for each period. In this sense it is necessary to emphasize that the ways of using technology, are themselves a form of technology. So also defined cybernetics.

In this way the different variables are exceptional approaches to materialize the integrated architecture, systems of thought or epistemologies, which were assembled to form these practices to project forms of interaction.

The direct influence of radical Bauhaus by Tibor Weiner, disciple and assistant Hannes Meyer, GATPAC Barcelona references, LeCorbusier concepts about teamwork, the idea of "active school" reform of the University of Cordoba, Argentina and the Free University of the Spanish Republic, the beginning of the industrialization projects Chilean government (CORFO), among others.

All these approaches are highlighted in the organizational setup of a social system identified with alternative models to the hierarchy, are also improved in the Essay Planning of Greater Santiago (EPGS), by Honold, Martinez and Correa, 1953. [10]

Some of these models are now considered explicitly to understand how systems of relations between people, through digital technology.

Patrick Geddes (1854 – 1932)

Biologist and botanist, focused on planning and education. Recognized by implementing the concept of "region", and the term "conurbation". A conurbation is the union of several cities or towns, for its growth. The term is used in geography and urban planning.

It is understood as a process or result of the growth of several cities (one of which can lead to the group), which are integrated into a single system that is usually hierarchical, although the various units comprising it can maintain functional independence and dynamic.

Concepts equivalent to Geddes in Chile, before the project EPGS. [11]

One way near as with the revaluation of Integral Architecture plan from the perspective of a Viable System Model (VSM) and Recursive according to the ideas of Stafford Beer, Geddes approaches, even though they were not known in the thirties, appear are plotted in the model of "Functional Unionism" ("Funcionalismo Sindical"), raised by teacher educators Nerve ("Nervio") group.

This is an association of teachers who had participated in educational reform as postulates of the "Active School" in 1928, which was testimony in the publication "architecture" ("ARQuitectura") of young architects Enrique Gebhard and Waldo Parraguez, in the year 1935. [12] Parraguez, like Gebhard, were leaders of the student movement of the School of Architecture in 1933, this publication presents a Parraguez theory about configuration, which could have anticipated the approach of Bonsiepe on Interface, 40 years later (Figure 12[xii], Figure 12[xiii]).

This group of teachers, after discontinuation of reform, regrouped in the city of Curicó, in southern Chile, periodically publishes a magazine, which culminated in 1935 in a book entitled "Syndicalism functional theory and practice ", where it is possible to match Geddes approaches,

with a susceptibility which synthesized ideas of educational experimentation, with the participation of communities, from a" organic "or" biologist "questioning the verticality.

The way to visualize these organizational relationships between the education system and functioning of the state (Figure 13[xiv]), seem to agree with the position of Geddes, who in the future will be brilliantly reinterpreted by three young professionals who make the EPGS.

Contemporaneously with them also, some leaders of the reform of 1928, these ideas redeployed within an experimental confederate schools policy during the second administration of Carlos Ibáñez, President of the Republic.

A projection of this second experience is confirmed by some of the young teachers to fulfill their professional practice in training them, and then be part of the formulation of the draft Unified National School (ENU), 1971.

The latter returned to raise both the importance of community involvement in the development of the public school, the importance of professional technical education.

Another principle coincides with the "recursion" Viable System Model of Stafford Beer with a history of "functional unionism" in 1935, as applied to the reinterpretation of the ideas of Geddes, who did the authors of the EPSG to the early fifty, anticipating what would be a "node theory" that would guide the essence of urban organic, is the principle of heterarchical or independence collaborative models decentralized alternative to traditional hierarchical organizational sense.

The idea of organizing "heterarchical" cyber engineer Stafford Beer is another "recursion" projecting from this experience.

Patrick Geddes defended the idea of social progress schedule through changes in the spatial form.

Geddes's ideas recognized by the New Technologies.

One of the greatest contributions to cybernetics Stafford Beer was his considerations he called second generation, in relation to the referent of Norbert Wiener.

For Beer Technology is not only industrially produced object, but also its usage, and more importantly the ways that cross interdisciplinary biology and the social sciences in the use of technology, in this case the information technology and / or through digital interaction processes.

In the particular case of Geddes, applications of this pioneer of urban planning in developing cities functioning with digital technology, GIS, [13] and planning done by computer, are investigated in the Geddes Institute for Urban Studies, University of Dundee. [14] Current interest aroused by this author focuses on the text "Cities in Evolution", which would have anticipated for about 100 years now generated debates in areas such as complexity studies, cities, morphology and design.

Gastón Bardet (1907 – 1989).

As a follower of Geddes, Lewis Mumford, this planner had a historicist and culturalist perspective.

Between the years 1947 to 1973 he was Director of the International Institute for Applied Urbanism Higher Brussels.

To Bardet the city is considered a body of organs with differentiated functions.

In their approach follows the concept: "Organization of the polycentric city," which the organization referenced Stafford Beer called "heterarchical" regarding our networking through digital technology, assuming operation "organicist".

Lewis Mumford (1895 – 1990)

Sociologist, philosopher of science technology, historian, philologist, urbanist. Decisively influenced by P. Geddes, had a historical and regionalist point of view about the technique, the city and the territory. Some of his notable publications as "Utopia and Garden City" or "The Myth of the Machine", exhibited cross reflection problems in science, technology, religion, psychology with emphasis of psychoanalysis, art, anthropology , aesthetic theory, biology and other areas of knowledge.

His proposals were evaluated by sectors of urbanism and architecture, and on the other hand, was attacked by those who defended the specialties, trying to marginalize.

Some of his texts as "History of Utopias" (1922), or "Stick and Stones" (1924), had an impact on architects like Walter Gropius and Mendelsohn.

In 1999 was published the correspondence between Munford and F. L. Wright, produced for 30 years as a result of empathy for both American authors with ideas of bio architecture.

His dedication to the text most urban theme was: "The City in History" (1960), developed in two volumes is a written exposes its fundamental concept regarding: "The city as a living organism."

This research raises a philosophical understanding of the variables overall aesthetic of the buildings, functionality, politics and sociology.

This research considers a critical reflective approach through history, philosophy, religion, politics, law and architecture. Establishing a gap between "democratic" technologies, in keeping with human nature, and technologies "authoritarian" in violent struggle against human values.

These ideas synthesized approaches to technology developed on patterns of human life and economy bioethics.

Reverend Joseph Lebret (1897 – 1966)
It is one of the founders of "Economy and Humanism" (1941), along with Francois Perroux. He had previously participated fishing cooperatives.
This movement posed a social studies approach to reality. This meant an overall view of the dynamics of societies and cultures.
In 1953 he was anointed as a member of the United Nations program "levels of development in the world."

Patrick Abercrombie (1879 – 1957)

He served as professor of "civic design" in the Liverpool School of Architecture in 1915. It is an influence on the movement "New Towns". This raises a defense motion to support rural areas.

Abercrombie is consolidated in urban development in London after 1944 as manager of the Grand Plan for the city.

The "New Towns" are a specific type of "Planned Community" or "planned city", which was carefully planned from its original conception and is typically built in an area still undeveloped.

This contrasts with aggregates as involving only appearance. The land use creates conflicts, if not collective use in the new cities.

One example is emblematic of New Town Brasilia (1956 - 1960), the architect Lucio Costa.

In Japan, as these ideas were projected 30 New Towns, through movement "Technopolis", which earned them be referenced by Manuel Castells and Peter Hall for his exceptional systemic structuring condition in 1980, within the parameters of "Inclusive Urban Development ".

Santiago Aguirre del Canto (1910 – 200-)

The Professor Santiago Aguirre collaboration, led by their own students, was fundamental. In a methodological sense Aguirre instructed the team title in the theories of political economy, and methodology of dialectical and historical materialist synthesis.

A circumstance that might seem unusual today, unprejudiced in this process, was very productive.

This teacher established a research methodology from its dialectical philosophical basis, which might seem incompatible with those not considered communists today, however the team of three students applied this methodology that made face specific problems, and generate synthesis, they found it while systemic support for organizing the plurality of principles with which they were working, to which are added several more of the above, but ultimately led to searches equivalent to a large set of projection methodology, following the principles of the city as a living organism, necessary to face an extremely complex challenges.

Aguirre led them to consider:

1) Objective reality
2) The mechanisms of cause and effect
3) The methodology of the general to the particular

Neo Organic Constructivism and Utopian Engineering.

This organic conception, is posed by overcoming a structural model modular, or modular system, one of NODE. Called by the civil engineer Abraham Freifeld U. 'node theory, "especially in the beginning on the design of ring roads (Figure 14 [xv]), and shortly opposed humanist synergistic (for lost 1-1 scale regarding landscape pedestrian) of the "road clovers", projected in the years 50, in other countries."

The difference is that in a modular structure, each part of the system has a specific function in a nodular, ideally every part of the power structure has all the functions of the system, that is the organic allegory for example with the genetic code applied to a way of doing design, but before that to define a model of society. The individual benefit is only possible to achieve through collective sustainability, and conversely each of the parts of a system have repercussions throughout the body.

Freifeld, holds a teamwork, from the Urban Planning Department belonging to Ministry of Construction and Physical Planning (1954 -1958/9), in coordination with the young architects from their ideas of the Integrated Architecture, had managed to insert their approaches of the city as a living organism within public policy planning, exceptionally.

But on reflection that this engineer poses on this model begins to identify some limitations of this under a cross-disciplinary still seem typical of other historical and conceptual context, more focused on the vision of objects, and that yet to respond to new developments.

By the late fifties and early sixties, the engineer decides to apply a model called Neo Constructivist Organic. Coupling the unified field theory of contemporary physics, with similar ideas of the new generation of Gestalt therapists' content compilers "that emerged in a reflection of the theory of perception" gestalt "of 1920, extending a reflection that arises from A link "synesthetic", from the inside out and vice versa, through the stages of emotional perception, desire, consistent with rationality. They are physical models of Fritz Perls, through his disciple Chilean Claudio Naranjo, which incorporates in applicable Freifeld, further bound to Eastern conceptions 'content compilers' energy, the Japanese KI, in the relationship between body and structure, making Aikido master. In this space understood from the perspective of the unified field (e = mc2) is called Engineering Utopian Freifeld, where the option is not to escape, but to "create an alternative" build.

The inverted pyramid, and a South American formulation of the concept Interfaze.

The specific condition that defines cybernetics, not only implement technology, but administration modalities. By the late sixties the ECOM, National Computer Company of Chile,

and similar instances, were in that search, comparing and sharing with countries like South American reality for these pathways.

At that time the industrial designer from HfG Ulm, Gui Bonsiepe, was leading the Technological Institute of Production Corporation (CORFO Intec), and in that place administrative tried a methodology for industrial processes and other variables achieved applying transfer theories use value, the field of aesthetics. In that context, he did a definition for interactivity, in the year 1972, and identified as Interface.

So if somehow trying Freifeld architects comprehensive answer, and his bio architecture, with a utopian engineering discipline contextualize the crossing, you would think that these searches about 1970 were a step to realize these principles in the new cyber platform, the transmission of information in real time, decentralized production models, as rehearsing visionary experience of the CORFO Cybersyn then. But this in turn was not unique to a single project, was rather a susceptibility period between professional disciplines related to the design at this time.

A landmark case in these senses is Stuven Hellmuth civil engineer, professor lighting, solar energy, and sound insulation, in the Faculty of Architecture of the University of Chile. And computer engineer Urban Improvement Corporation (CORMU), inclined to quantum physics research, and their approach to the unified field.

Stuven then applied software programming activities Pert / CPM, in the design of social housing 5 models, to start the pledge of 100,000 homes in 1971. But it goes further.

Unlike traditional logic 'top down', for the proposed construction scheduling of the building to the Third United Nations Conference to Trade and Development (UNCTAD III), to be held in April-May 1972, in Santiago de Chile, following the logic of "committee work" construction company "Desco"; Stuven 75 foremen trained in handling the Gantt chart, software PERT / CPM, and entering information on IBM cards then. This Stuven called "inverted pyramid" as in communication theory.

La conference of UNCTAD III unfolded a discussion by an alternative model of modernity, but the way that was used technology in its construction, including application of digital technology and their interfaces, were in if same a demonstration of this progress "heterarchical ", a modernity centered in interdisciplinary integration from a sense humanist more organic.

With this logic exceptional work, the project organized innovatively through "critical diagram" of the software, was achieved with the collective work of even three shifts, in 275 days, being a work of these features then took about 3 years.

At that time also (1971), the Chilean biologists Francisco Varela and Humberto Maturana published his book: "From living machines" where specifying the behavior of the immune system, as entities 'autopoietic'.

In the introduction to a new edition, 1994, Francisco Varela explains that the concept of autopoiesis was referring to the behavior of the immune system, not only as a reaction to

pathogens, but also as a behavior with an internal logic independent pathogenic stimuli. This thinking influenced many fields in the social sciences, and even in cybernetics. [15]
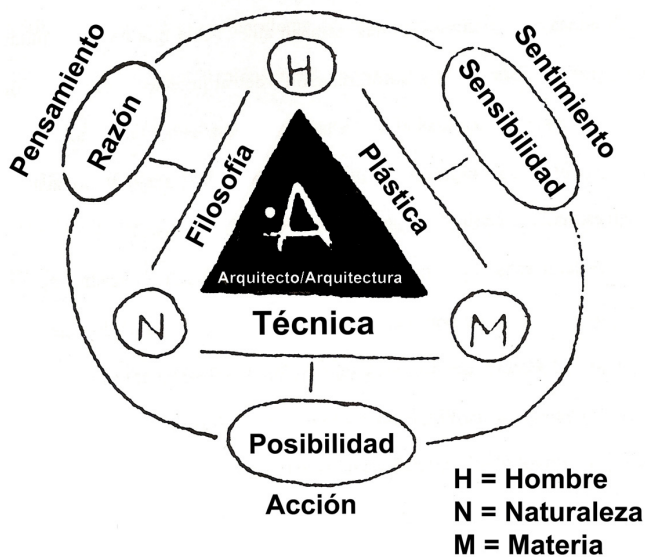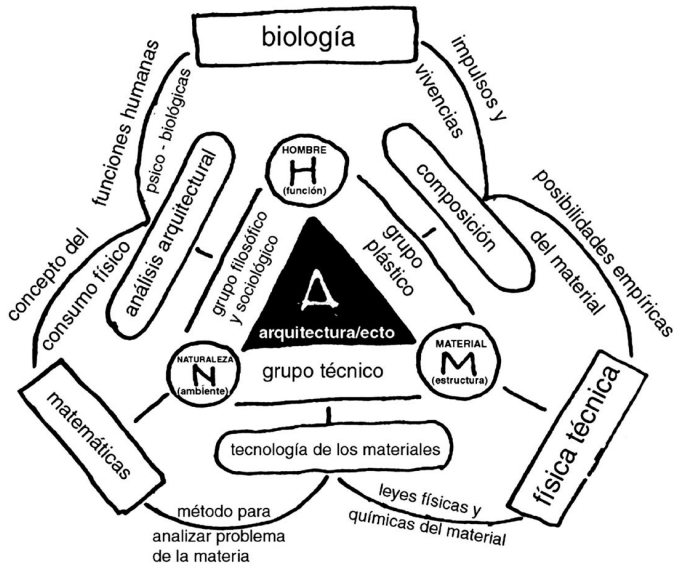
Vir-Det (1989) y Oyster (1990).

In a context totally opposed to its predecessors, inserted fully into the state development, however in the late eighties, the Chilean Bachelor of Medicine, and self-taught engineer, Miguel Giacaman, developed one of the first computer antivirus in the world, where components behave as would the immune system that is transforming its structure according to the new conditions of the agents 'pathogens'.

This is how successfully implemented Giacaman Vir-Det antivirus in 1989, and then the Oyster. Acquired by IBM in the early nineties, after he was able to repel the attack of one of the most damaging computer creations of these years, generated by a technician of Israel.

This would tend to trans generational prospective future models as: Participation + Learning Organization: Reform (action). To what from now on, perhaps, we could further develop and architecture Digital Bio, projected from our own conditions to achieve intersections between humans, technology and the environment, through dynamic balances.
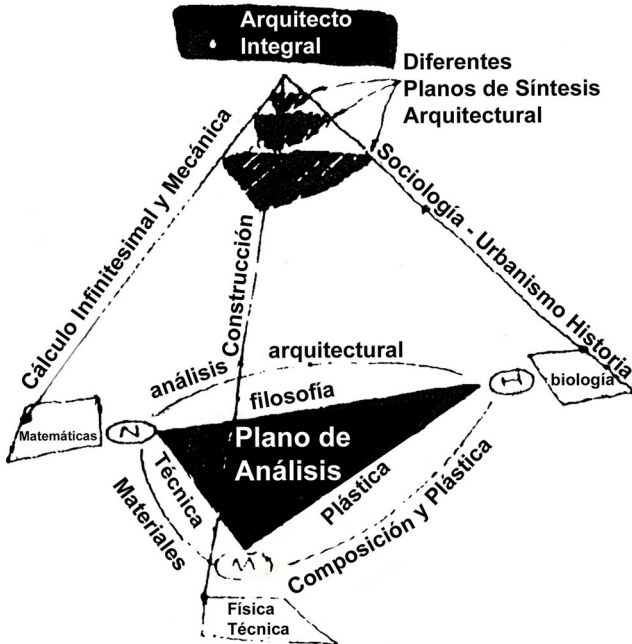
"Facultad de Arquitectura, Universidad de Chile, Espíritu del plan de estudios", Revista "Arquitectua y Construcción, Chile", n° 11, diciembre de 1947, p. 41.
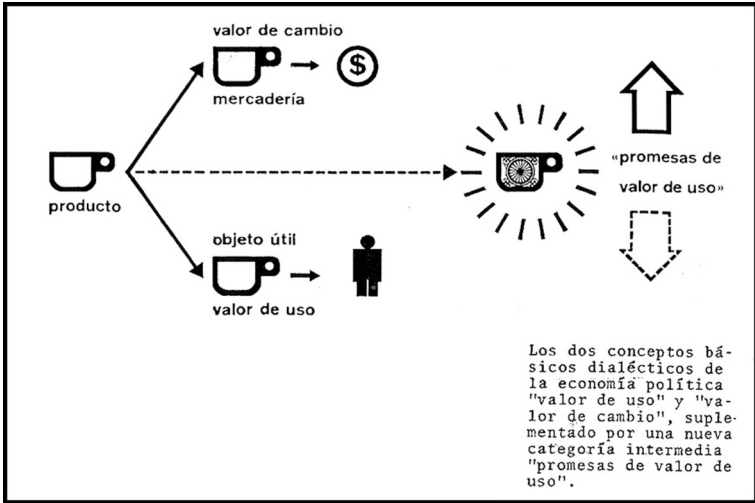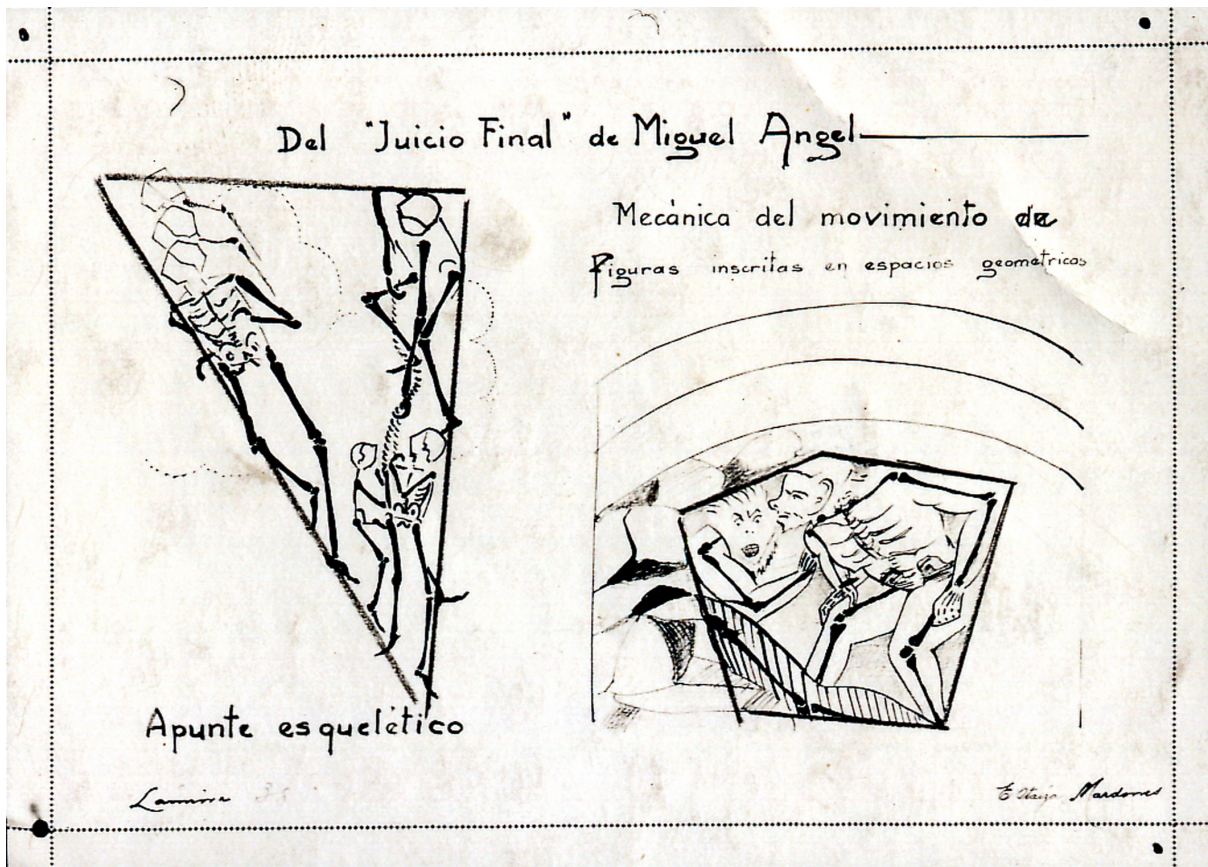
biología

impulsos y vivencias

funciones humanas

psico - biológicas

composición

posibilidades empíricas del material

concepto del consumo físico

análisis arquitectural

HOMBRE H (función)

grupo plástico

grupo filosófico y sociológico

A arquitectura/ecto

NATURALEZA N (ambiente)

grupo técnico

MATERIAL M (estructura)

matemáticas

física técnica

tecnología de los materiales

método para analizar problema de la materia

leyes físicas y químicas del material

(Revista "arquitectura y construcción, CHILE", nº 11, diciembre 1947, pp. 41 - 43)

Arquitecto Integral

Diferentes Planos de Síntesis Arquitectural

Cálculo Infinitesimal y Mecánica

Construcción

Sociología - Urbanismo Historia

análisis

arquitectural

filosofía

Matemáticas

N

Plano de Análisis

biología

Técnica

Plástica

Materiales

Composición y Plástica

M

Física Técnica

-454-

Los dos conceptos básicos dialécticos de la economía política "valor de uso" y "valor de cambio", suplementado por una nueva categoría intermedia "promesas de valor de uso".

Anrée Haas, por Víctor Blanchi

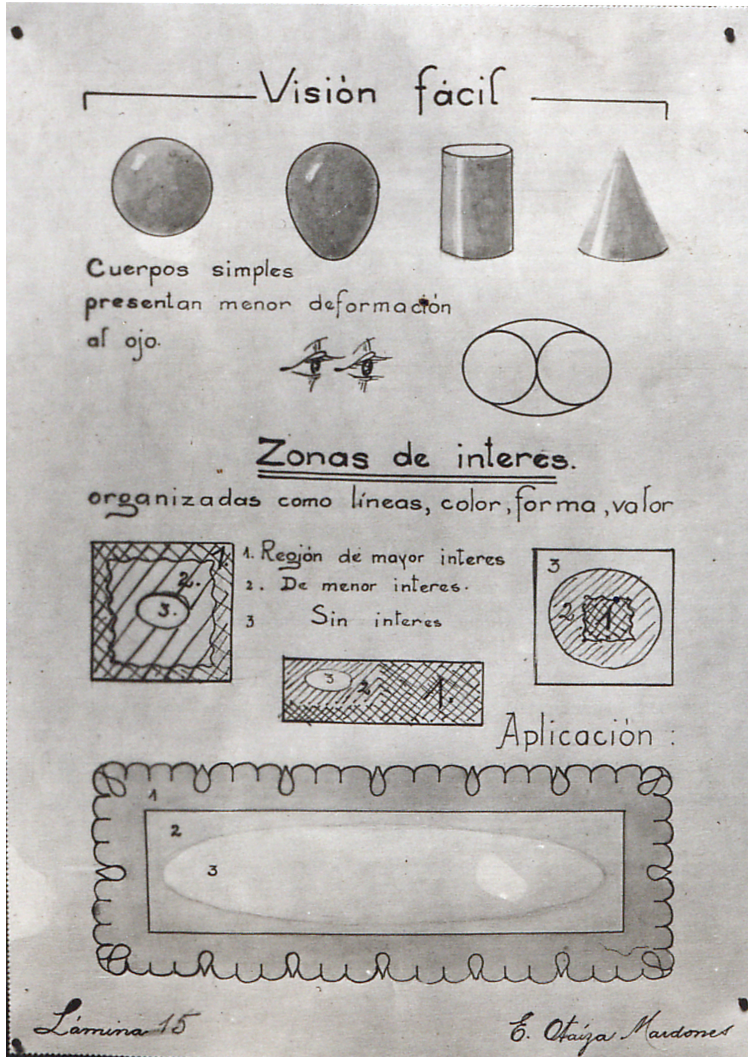Del "Juicio Final" de Miguel Angel _____ Apunte esquelético

Mecánica del movimiento de Figuras inscritas en espacio geométrico

Lámina nº   F. Oteiza Mardones

Visión Fácil

Cuerpos simples
presentan menor deformación
al ojo

Zonas de interés
organizadas como líneas, color, forma, valor

1. Región de mayor interés
2. De menor interés
3. Sin interés

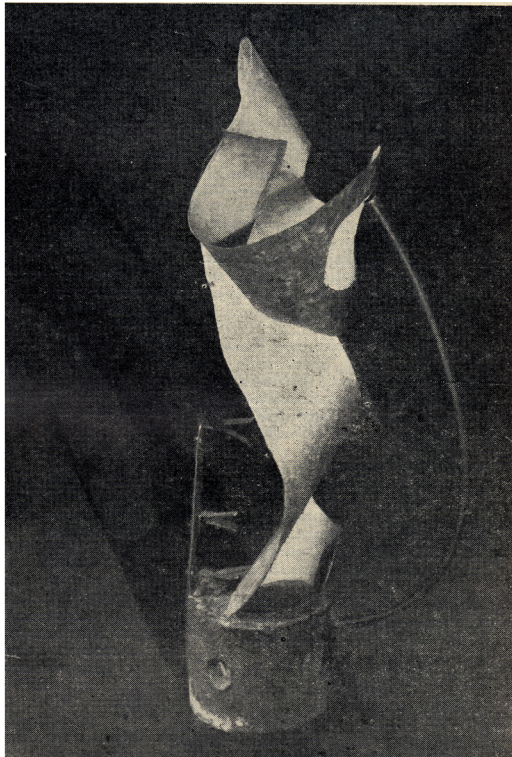Aplicación
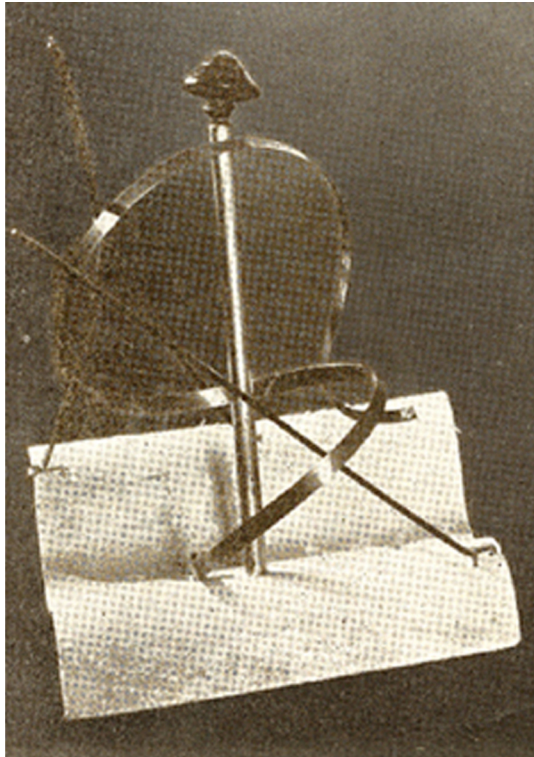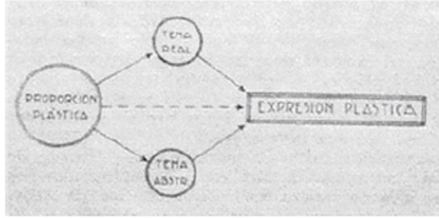
Lámina nº 15

F. Oteíza Mardones
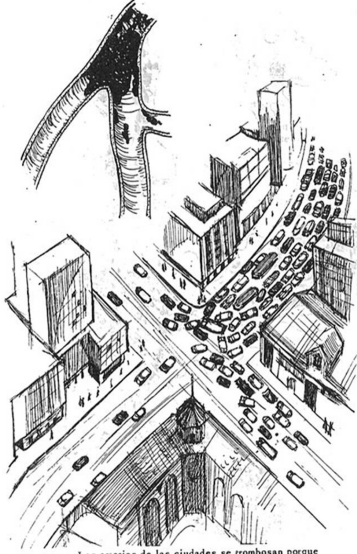
Las arterias de las ciudades se trombosan porque no siguen normas biológicas, ni en calibre, volumen, ni velocidad. La circulación de vuelta es reciente.

Las ciudades se mueven como las amebas. Santiago ha emitido pseudopodios a diferentes barrios y ha parado. Ahora avanza a Vitacura.
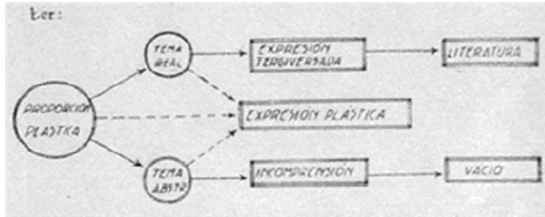
COMER

ASEAR

"RELACIONES TEMPORALES"
"UNIDADES ESPACIALES"

"MENOR PORCION DE ESPACIO QUE TIENE VIDA PROPIA"
"MOLECULA" (U.E.)

DESCANSAR

RELACIONARSE

ASEARSE

MADRE
PADRE
HIJO (18 AÑOS)
HIJA (18 AÑOS)
"BEBE" (1 AÑO)
VISITAS

CIRCULACION

(DIAS DE "TRABAJO" Y DIAS DE DESCANSO...)

ALIMENTOS

DORMIR

SECUENCIA - FRECUENCIA - INTENSIDAD

CIRCULACIONES AMBIENTALES
PLANOS LIMITES (PARAMENTOS)

PROFESOR: ARQTO. TIBOR WEINER
TALLER DE ANALISIS ARQUITECTURAL Y URBANISTICO
PRIMER AÑO, TERCER PERIODO - ALUMNO: R. TAPIA CH. - 1946

TRABAJAR ESTUDIAR

TEMA
REAL

PROPORCIÓN
PLÁSTICA   EXPRESIÓN PLÁSTICA

TEMA
ABSTRACTO

TEMA REAL	EXPRESIÓN TERGIVERSADA	LITERATURA
PROPORCIÓN PLÁSTICA	EXPRESIÓN PLÁSTICA	
TEMA ABSTRACTO	INCOMPPRENSIÓN	VACÍO

ESTADO SINDICALISTA FUNCIONAL

Socialista, democrático, unitario, descentralizado, aburocrático, sin
clases ni partidos, ORGANICO.
Individuo y Estado se identifican en los grupos funcionales
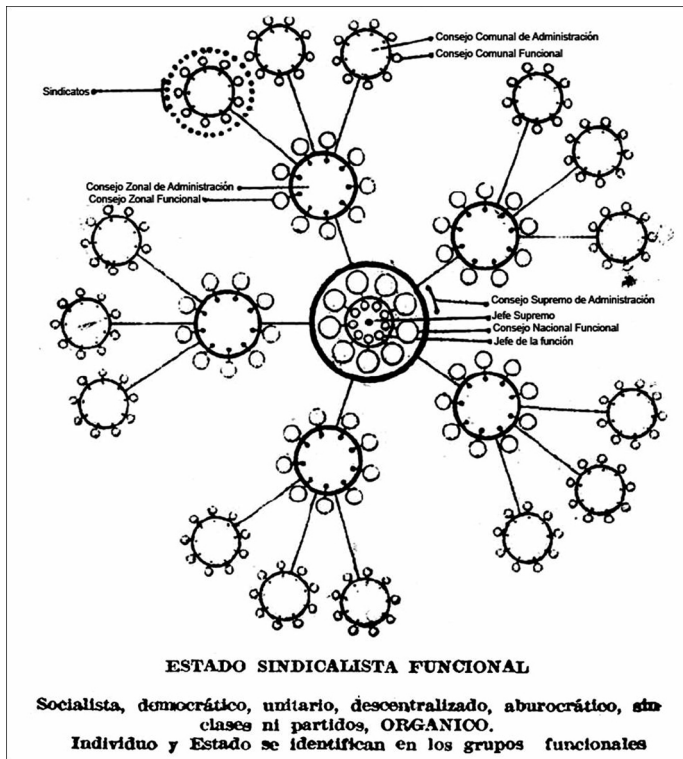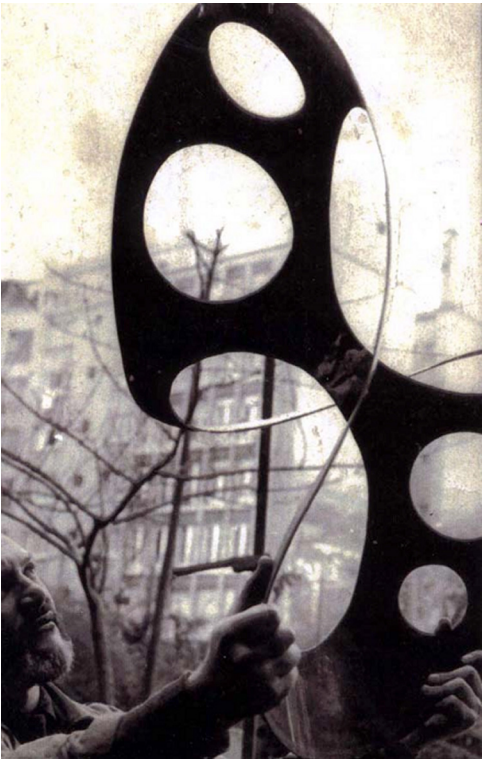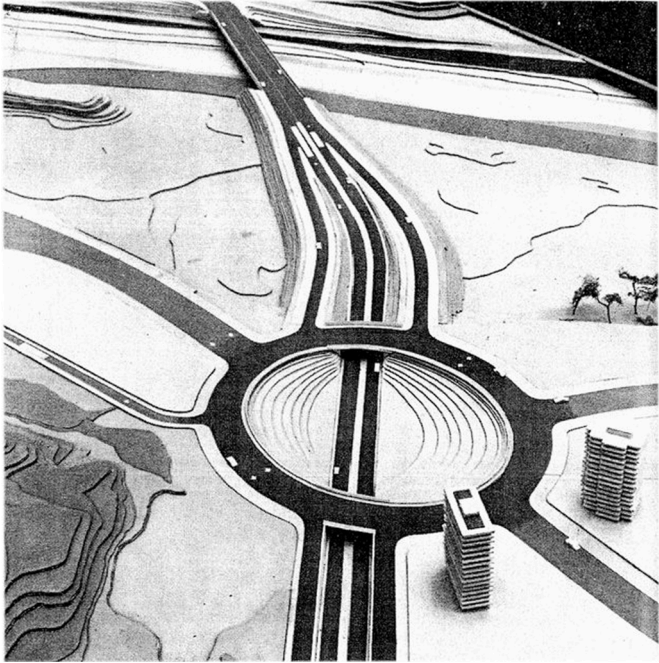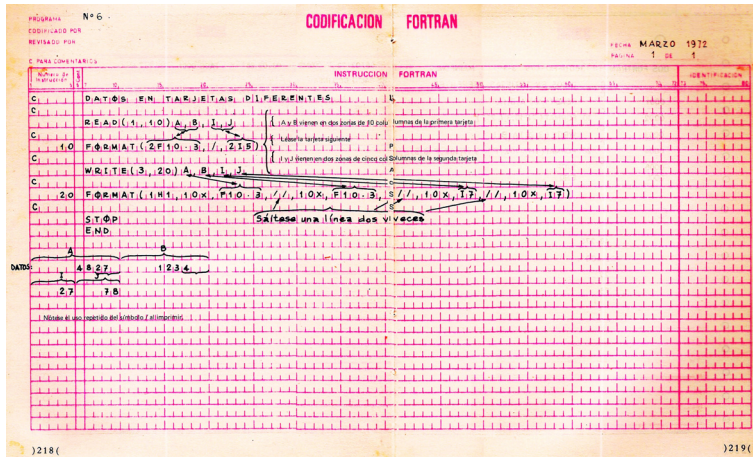
Notes

1. Beer, Stafford. "Brain of the firm", 2nd edition, John Wiley, London and New York, 1981.

2. "Facultad de Arquitectura, Universidad de Chile", Revista Arquitectura y Construcción, Chile, n° 11, diciembre 1947, pp. 41 – 43.

3. Freifeld Umanski, Abraham. The Spatial Arts, unpublished manuscript (1995).

4. Martinoya, Carlos. Joel, Nahum. "The ¨chromatic abstractoscope¨: an application of polarized light", Leonardo, Vol.1, n°2, Apr. 1968, p. 171.

5. Bloch, S., Orthous, P. & Santibáñez-H, G. "Técnicas psicofisiológicas para el entrenamiento de actores", Orbita, 1972, 9:8-20.

6. "Revista del Domingo", El Mercurio, 1971.

7. Bonsiepe, Gui. "VI/VI/SEC/CIÓN del diseño industrial", Revista AUCA, Arquitectura, Urbanismo, Construcción y Arte, nºs 25/26, 1972.

8. Barrenechea, Ana Maria/ Behm, Hernán/ Cáceres, Osvaldo/ Ehijo, Francisco/ Esquenazi, Raquel/ González, Sergio/ Lawner, Miguel/ Tapia, Ricardo. "A 53 años de la Reforma de la Escuela de Arquitectura de la Universidad de Chile", Unpublished paper presented at the anniversary of the Faculty of Architecture and Urbanism of the University of Chile, 1999.

9. Bureaud, Annick. "Qu'est-ce qu'un média ?", "Qu'est-ce que "l'art des nouveaux médias" ?", Les Basiques : Art "multimédia", Le projet Les Basiques de Leonardo/Olats (l'Observatoire Leonardo pour les Arts et les Techno-Sciences), 2004. www.olats.org.

10. Correa, Pastor. Retrospectiva de un Ensayo de Planificación del Gran Santiago, 1953. Edita Universidad Central de Chile, 2002.

11. EPGS: Essay Planning of Greater Santiago, 1952. Note: in spanish the words essay and assay are the same "ensayo".

12. Note: You must also consider that in 1934 was a great Pan American Urbanism Seminar, in which self-proclaimed representatives Chileans as the best prepared to found a Pan American School of the discipline, performing in 1938 the Chilean Congress of this branch of architectural planning and engineering.

13. GIS: Geographic Information System.

14. http://www.dundee.ac.uk/geddesinstitute/about.htm

15. Maturana, Humberto/ Varela, Francisco. "De máquinas y seres vivos. Autopoiésis: la organización de lo vivo", Editorial Universitaria, Chile, 1994.

Notes on figures

i.   Figure 01. Based curriculum for the Integral Architect: human being + nature + matter. School of Architecture, University of Chile, 1946.

ii.   Figure 02. Interaction of the three basic elements of the curriculum of the Integrated Architecture. School of Architecture, University of Chile, 1946.

iii. Figure 03. Designing of stages: analysis and synthesis, the Integral Architecture. School of Architecture,

iv.   Figure 04. In the late sixties, a group of two psycho physiologists, Susana Bloch and Guy Santibañez, did research with the theater director Pedro Orthous on training techniques of actors.

v.   Figure 05. Gui Bonsiepe`s scheme to explain the importance of the use value of aesthetics in industrial design, 1972. Image first published Intec Corfo journal, and then Auca Magazine.

goal of unifying perceptual fields, both contemporary physics, as theories of gestalt post formalist.

xvii.   Figure 17. Instructions for entering information on an IBM card, in March 1972, Chilean high school student handbook. Authors Ines Jaime Harding and Michelow, Editorial Universitaria.

The Cross-Disciplinary Challenges of Visualizing Data

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Rikke Schmidt Kjærgaard, Assistant Professor, Interdisciplinary Nanoscience Center, Aarhus University, Denmark

Miriah Meyer, Assistant Professor, computer science, University of Utah, U.S.
Bang Wong, Creative Director, Broad Institute of MIT and Harvard, U.S.

Introduction

Data are growing intensely and pose a substantial data visualization challenge. Every day we generate massive amounts of data in the form of photos we take, electronic messages we send, and queries we make to Internet browsers. Numbers of shared data have more than doubled during the past five years (Internet World Stats). The complexity of collecting and analyzing big data in meaningful ways challenges and changes the fundamental of research, impacting research methodology itself and our approach to tool design. From medicine to sociology, analysis of quantifiable data about life on Earth has allowed researchers to gain new insight making us better understand genetic and molecular underpinnings of disease. Analyzing big data encourages new research questions, triggers new data interactions, and motivates new research technologies and methods. In particular, we experience an enormous increase in development of visual technologies, tools and methods for exploring and analyzing data. Making sense of data visually is fundamental to most research processes. We depend on visual patterns and guidance in everything we see. When reviewing an article in a journal, we first explore graphics and visual representations before reading the actual paper. Visual representations and analytical tools have the potential to augment our reasoning capacities by facilitating perceptual inference, discover patterns, and expand our working memory.

Visualizations have emerged as an important component of understanding and interpreting data. In the emerging field of visual analysis, several key areas of focus exist: 1) analytical reasoning techniques (enabling users to obtain deep insights directly supporting assessment, planning and decision making); 2) visual representations and interaction techniques (allowing users to see, explore, and filter large amounts of information into intelligible partitions); 3) data representations and transformations (converting all types of conflicting and dynamic data in ways that support visualization and analysis); and 4) techniques to support production, presentation and dissemination of the results (in the appropriate context to a variety of audiences) (Thomas & Cook 2005: 4). These focus areas are to be pursued through collaboration and interaction between subjects such as scientific analytics, information analytics, knowledge discovery, cognitive and perceptual science, expertise data management, geo-spatial analytics, human-computer-interaction, and many more (Keim et al. 2006). A cross-disciplinary framework

is fundamental in practicing successful data visualization and is the substance of the challenges presented in this paper.

Challenges

The access to massive amounts of data together with an urgent need of tools to help us process information and create reliable representations have fostered the current trend of exploiting visual methods for discovering new knowledge and helping in decision-making processes. Most research disciplines are using visualization techniques to interpret and gain insight into the huge volumes of unstructured data. In our work we have identified two major challenges for data visualization and information design:

The lack of communication and exchange of visual methods, tools and strategies across different research areas, resulting in unnecessary duplication of efforts.
The lack of a common set of skills as a basis for more effective collaborations between people in different fields to develop and improve visual tools.

While we see domain specific efforts advancing visualization techniques, they often remain part of the knowledge of these particular communities, and are rarely shared across domains. For example, there are two main venues for visualization of biological data: Visualizing Biological Data (VIZBI) and BioVis (part of the Institute of Electrical and Electronics Engineers' VisWeek). Although these meetings intend to integrate disciplines, few biologists attend (the expert domain side of these projects). It is necessary to explore integrative ways of sharing efforts in devising visual methods so as to help advance, not only the field of data visualization, but also the areas in which visualizations help advance knowledge.

Visualization tools and software solutions are increasingly designed to facilitate particular projects, data or results, and rarely offer a general approach. Furthermore, making such tools is often expensive and time consuming, requiring methodical approaches from practitioners in many disciplines, and can only be done in highly interdisciplinary collaborations between scientists, computer scientists, data designers, scientific illustrators, and many more disciplines. This constitutes a significant challenge for data visualization. What is needed is a 'common language' and shared skill sets that transcend conventional professional boundaries from computer science to graphic design. A research team needs to be able to interpret the underlying structure of a dataset in a very abstract, algorithmic way, as well as understand the process of mapping data attributes to specific visual encoding channels — skills that are natural extensions of basic computer science principles. Similarly, practitioners need to be able to extract the tasks and define the visual representations that will best capture the essence of the dataset — skills that relate to fundamental concepts found in design. Practitioners of data visualization need to work in multidisciplinary environments and communicate with field experts in order to extract knowledge about specific application areas — competences of critical analysis, communication abilities, and social skills are all highly important in a successful collaboration.

In our personal experience, each of us had a subset of these required skills and had to learn the others in order to have meaningful interactions with each other. Countless resources have shortened the way to knowledge. Technologies and databases offer free access to a number of

documents, files, figures, numbers, facts, etc., telling stories about the world we live in. We now need to ask: How do we gain proper and relevant insight? How do we define the appropriate methods to explore, analyze, and communicate information? How do we go about teaching these skills and methods to the upcoming generation of visualization practitioners and data scientists? We argue for a more effective, structured and scalable way of doing this, rather than the serendipitous trajectories that we ourselves went by. We see several major challenges ahead for data visualization, from education of future generations of data designers to supporting mechanisms to those already working in the field. We ask, can we define a common knowledge base and think differently about teaching computer science and design principles with the goal of visual analysis in mind? How do we bring these common sets of skills to cross-disciplinary teams of current practitioners?

Suggested actions

To answer these questions and to meet the cross-disciplinary challenges of data visualization set out by this paper, we present the following suggestions to advance the ongoing effort in the field of data visualization:

Establish channels for cross-domain communication (e.g., professional meetings, peer-reviewed publications, community maintained web-based forums, etc.)
Develop an interdisciplinary common ground.
Carry vision for funding bodies on the potential payoffs for cross-domain initiatives.

1. Establishing channels of cross-domain communication

The suggestion and ambition of creating a common platform for knowledge exchange is aimed at a diverse data visualization community, including data producers, data designers, graphic designers, computer scientists, analysts, illustrators, etc.

Most of us use visual methods and tools to synthesize information and data. We do that to analyze and reason about our questions and subjects, to discover patterns, to understand structural features, and to communicate ideas and results effectively, etc. However, current methods for data visualization and information design are dispersed and rarely subject to cross-disciplinary knowledge exchange. Individually, all disciplines involved in data visualization advances the research and practice of visualizing data by devising new visual methods, new algorithms, and new design features, etc. Individual research communities share their best practices in domain specific conferences, meetings and journals. Researchers only join other parties out of sheer curiosity or by coincident, and their knowledge rarely overlaps without self-motivated pursuit and communication. For data visualization to advance as a distinct research field we need more immediate interaction and direct knowledge sharing. A common platform for knowledge exchange and sharing of best practices would provide that. Such a platform would not only strengthen research interaction, tool development, and design ideas for data visualization, but also provide valuable knowledge of design initiatives and methods that failed to perform as expected.

To encourage cross-domain and interdisciplinary exchange we suggest creating platforms including cross-disciplinary meetings, research conferences and workshops, and online open repositories for sharing knowledge of ongoing and concluded research projects, published papers, current tools and method databases, call for papers, etc. allowing documentation, storage, search, evaluation and retrieval of research and knowledge related to data visualization and information design. It will be advantageous if strategies, methods and tools created in a particular field are accessible to other domains. We are a growing community of practitioners in the field of data visualization. Having a common ground and means to share experiences can help advance the field, and further encourage interdisciplinary cooperation and collaboration.

2. Developing an interdisciplinary common ground

The suggestion of creating a necessary interdisciplinary common ground encourages and emphasizes the desire and need of a common visualization ground at university level. This common ground for discussion and collaboration is aimed at members of the diverse data visualization community in academia.

Currently, few strategies defending or describing a common ground in data visualization and information design exist. New developments of tools and methods tend to be subject to casual and individual demands, subjective design ideas, visual consensus in the particular field, and lack of visual training for the information designer or data analyst. As pointed out in the previous section, the education of young researchers is also constrained to domain specific techniques and students are rarely exposed to or encouraged to use visual analysis methods from other fields. The curriculum, and hence the education of students working with any kind of data visualization, tend to be narrow in focus, leaving any use of untried ways or reasoning up to the individual student. There are several initiatives that promote numerical literacy across all ages and gender: from incentives toward strong mathematical and scientific foundation in K-12 education, to encouraging women to embrace STEM education. But there is hardly any initiative that universally addresses the need for spatial and visual thinking along with analytical and numerical reasoning. The challenges posed by big data and the burgeoning practice of data visualization require us to rethink educating of the next generation of data visualizers at university level.

With the objective of bridging engineering and design aspects of data visualization, and thereby advance educational settings and curricula, we suggest forming taskforces to trace and outline a common pedagogical approach incorporating visual and analytical, statistical and computational core values and techniques. A proposed common ground and educational basis would include the analytical and data oriented models and methods from computer science, allowing a common language for structure and complexity of visualization systems. From the arts and design, we would suggest including the perceptual and human centered methods and strategies, allowing for a discussion of form, perspective, and usability. We believe that the basics of these two areas of enquiries and two ways of reasoning can be brought together, enriching the way we communicate in collaborative groups as well as adding skills that can benefit the way we work in either one of these groups. The effort will encourage disciplines to adopt curricula that are domain specific while attending to interdisciplinary pedagogical needs.

3. Funding cross-domain initiatives

Recognizing the importance of diverse skills for developing effective visualizations means providing resources for researchers and practitioners to come together to reach a common goal, while also pushing the boundaries of their individual domains. Funding agencies need to financially support a holistic solution to dealing with big data, which includes funding a broad range of research areas that approach the problem from different perspectives

There are funding opportunities in place for visualization research that we consider fundamental and that should continue as they help advance the visualization field in general. However, there seems to be a lack of funding for tackling visualization research (broadly construed) in the context of driving, real-world problems. For example, in tackling a specific biological question, the need for, and difficulty of, developing appropriate techniques and tools for making sense of the data should be accounted for in funding proposals. Proposals that include (equal) partnerships between application experts and visualization researchers should be encouraged, with appropriate resources for both fields to advance.

Furthermore, we suggest providing additional funding for encouraging cross-disciplinary initiatives as those described in suggestions #1 and #2. We believe that supporting the study of interdisciplinary teams across domains will be needed if we are to define and promote a common visualization platform and educational system. Funding could support, for example, launching selected pilot pedagogical projects to pioneer suggestion #2, as well as for archiving and retrieving research from diverse domains as described in suggestion #1.

Final Thoughts

Data is meaningless unless we can reason about it and ultimately gain insight through analysis. One of the main challenges we face in research environments working with big data is to find appropriate methods and strategies to make sense of and advance knowledge in academia, businesses, and government. To meet this challenge this paper focuses on visualization methods in terms of facilitating analytical reasoning processes in diverse research domains. Visualization is one method to address complexity, we believe it is the most ubiquitous, and one that can be used in meaningful ways together with other techniques, as it effectively actuates our sensory and cognitive systems. However, in order to advance the field of data visualization we need to create common grounds for sharing knowledge across domains, while also advancing curricula to prepare a new generation of practitioners.

References:

Thomas J.J. and Cook K.A. (editors) (2005) Illuminating the Path: The Research and
    Development Agenda for Visual Analytics. IEEE Press.
Keim D.A., Mansmann F., Schneidewind J., and Ziegler H. (IV 2006) Challenges in Visual Data
    Analysis, Proceedings of Information Visualization. IEEE, p. 9-16.

Exploring a Model of Inter-Disciplinary Research Collaboration Based on Collective Action Theories

http://wp.me/P2oVig-pY

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The objective of this paper is to develop the first schemes of a possible methodology based in the Theories of Collective Action to analyse and facilitate transdisciplinary dialog and collaboration between science, engineering, art and design. Such theories are usually applied to understand different kinds of collective actions (for example, regarding actions that appear in ecologist, feminist or pacifist movements, among others). We propose that these theories can also be pertinent to analyse, in a very structured way, the interaction between the main dimensions, agents, resources, contexts and strategies of transdisciplinary action. Therefore we will use these theories to frame a method for identifying the main elements that constitute this kind of action in general and in particular between art, science, design and engineering. This methodology could support action coordination towards transdisciplinary collaboration addressed to different stakeholders taking as reference the distinctions between 3 kinds of collaboration, introduced by Allen F. Repko (2012:20)[1].

The hypothesis is that collective collaboration in transdisciplinary research environments can be understood as a form of collective action according to the following definition:

"Collective action is the result of a social action (or collective challenge) carried out by the set of formal and informal interactions established between (1) a plurality of individuals, collectives and organized groups (who share, to a greater or lesser extent, a sense of belonging or collective identity among themselves) and (2) other social and political actors with which they come into conflict. This conflict is triggered by the appropriation (of), participation (in), and transformation of relations of power to achieve social goals, and above all, through the mobilization of certain sectors of society" (Tejerina, 2010:19).

Repko's definition helps us to understand that despite the different forms in which transdisciplinary collaboration has historically developed there has been a constant core around

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[1] According to Repko (2012:20) "multidisciplinarity studies a topic from the perspective of several disciplines at one time but makes no attempt to integrate their insights […]. Interdisciplinarity studies a complex problem […] by drawing on disciplinary insights (and sometimes stakeholder views) and integrating them […]. Transdisciplinarity concerns that which is at once between the disciplines, across different disciplines, and beyond all disciplines […] and seeking to integrate disciplinary and stakeholder views […]."

which different ways, objectives, motivations and concerns spun towards its achievement. This core is the social need to deal with (1) topics, (2) complex problems or (3) knowledge about the world in a unified sense, that goes beyond the capacity of each discipline and implies a collective endeavor materialized in actions. Therefore it is crucial to understand how these collective actions are shaped by means of discussions, negotiation and re-negotiation processes according to specific historical and cultural circumstances.

The development of a typology of different categories of analysis to understand transdisciplinary collaboration actions can be crucial to fully support and ground such actions, making the most of possible resources and finding the right institutional, educative and social framework for their development. Transdisciplinary action is a dependent variable in relation to a few key elements that are categorized in the theory of collective action. The translation of these elements can serve to generate a specific action theory for collaboration between disciplines. These elements are:

(1) Why, where, when and in which way collective action happens (Theory of Collective Behaviour, Smelser, 1963). In the case of NSEAD action the same questions apply;

(2) The relationship between costs and benefits of collective action, that is to say, the dependence of collective action on available resources, group organization and opportunities and on the strategic and political factors involved (Theory of Resource Mobilization, McCarthy and Zald, 1977; Jenkins, 1983; Zald and McCarthy, 1987). In the case of NSEAD action the same is valid;

(3) Context interaction (Theory of Social Interaction, Turner and Killian, 1957), in the case of collective action, translates into the concept of NSEAD's context interaction;

(4) Political aspects (Theory of Structure of Political Opportunity, Kriesi, 1995; Tarrow, 1989, 1994; 1998), present in collective action, is also valid for NSEAD action.

(5) Collective sense and aims (Theory of Collective Identity, Melucci, 1995), as in collective actions, there is a blend of intentions, resources and limits. Collective actions imply intentional decisions and interaction structures inside a system of opportunities and restrictions. There is a need to build a sense of belonging to a collective, in relation to transdisciplinary action.

The concept of "interaction structure", that is central in the case of a social movement, frames the environment that "enables the existence of a series of interactions (Tilly), or the network of informal interactions between a plurality of individuals, groups or organizations (Diani, 1992), or that a group acts in a continuous way (Turner and Killian, 1957)" (Tejerina, 2010:20). In the analysis of these interaction structures, all dimensions in which an action takes place, micro, mezzo and macro, must be taken into consideration. In the case of transdisciplinary collaboration, the very researchers are those who produce face-to-face actions, negotiate strategies within organizations, coordinate their own actions in relation to other institutions, dialogue with decision-makers, have access to media and promote sensibilization actions to increase consciousness regarding this kind of collaboration. In our case, NSEAD can be an

example of this thread of actions across many spheres and scales of activity that recommend actions to be taken according to different levels of agency.

The concept of interaction structure can also be essential to analyse how transdisciplinary research and creative work, learning and knowledge transmission processes develop (regarding agents, ways, tools and environments) because transdisciplinary agencies (researchers, managers, decision-makers, funding institutions) interact in different degrees in all these spheres and scales. Therefore it is necessary to see how these interactions are produced and coordinated (either in a positive or in a conflictive way) and the effect of these actions on improving the conditions of transdisciplinary action and research across science, engineering, art and design.

According to the theories of action (Tejerina) the most important interaction structures that shape collective action happen in different spheres. Some happen in face-to-face situations particularly between peers inside each group or collective (Melucci, 1995; McAdam, 1982); some within each organization or institution (Klandermans, 1997; McCarthy and Zald, 1977); others emerge from the challenges that social actors (in our case, artists, designers, engineers and scientists) pose to elite decision and policy-makers (McAdam, Tarrow, Tilly, 2001) and those that spread and impregnate society in an invisible way. The processes of interaction that happen in each one of these structures and between themselves shape how successful action can be.

Having the broad matrix of these structures will improve our capacity to suggest the best actions to different stakeholders, especially to those in the position of making decisions; to identity and overcome obstacles and to enhance opportunities for collaborative action across science, engineering, arts and design.

The method: Nature, type and scale of stakerholders and type of action

The method is developed as a tridimensional matrix taking into consideration different kinds of actions, crossed with different kinds of agents and their spheres of interaction between each other. The aim is to explore opportunities and obstacles to develop transdisciplinary collaboration, analyse how it is emerging and plan future actions. Time will add a fourth dimension to the matrix.

The method can contribute to improve the vision on how transdisciplinary actions change knowledge production and how the aims, motivations, and interactions around transdisciplinary problems synchronize and find resonance (or not) in an environment of limited resources and changing opportunities in which there are collaborators and opponents that need to dialog.

In this sense each suggested action must be related to the big picture but addressed to each different stakeholder in its own sphere of action (for example: artists, designers, engineers, scientists, educators, funding agencies). We can differentiate between 4 kinds of stakeholders: individuals, communities, public institutions and private institutions.

Actions analysis should take into consideration basically two kinds of agents: sympathy and resistance agents. Sympathy agents are individuals, collectives and organized groups that work to facilitate transdisciplinary dialog and collaboration around similar or equal objectives.

Resistance agents are other social and political actors with which they come into competence or conflict.

In addition to 6 kinds of actions, the analysis takes into consideration 4 types of stakeholders such as individual, communities (structured and formally organised, like professional associations, and *ad hoc* interest alliances, linked to disciplinary fields) and public and private institutions (not linked to disciplines like banks for example), acting in 4 scales (local L, regional R, national N and international I scales).[2]

The actions that can be considered have been grouped into these 6 categories:

1) (AR) Actions for the increasing of resources (including advocating)
These actions aim at getting more access to funding, human and technological resources to research and collaboration across disciplinary borders.

2) (NA) Actions to support networking
The aim of this kind of actions is to foster engagement, participation, formal and informal actions for exchanging knowledge and networking actions. Resilience and solidarity actions for supporting networked projects (NSEAD can be a kind of big umbrella for different projects and institutions towards the aim of fostering networked achievements).

3) (EA) Education actions to prepare researchers to manage transdisciplinary collaboration
Education actions are aimed at preparing researchers to manage collaboration across disciplines, develop a common language and deal with differences. In particular, it is necessary to solve questions around methodological and theoretical dominance of one discipline on others and questions around theoretical and methodological integration and developing adequacy (Repko). As Repko said, multi-disciplinary approaches the 'home' discipline usually imposes the preferred method and theory, transdisciplinary approaches do not give preference to any disciplinary method or theory and trans-disciplinary approaches integrate all knowledge, disciplinary methods and stakeholder views on the basis of some overcharging theory.

4) (ARS) Actions to support research (for researchers)
These actions involve listening and follow up, to maintain a system of tracking opinion from researchers in the network. The purpose is to update the cartography of researchers on the network and their results of their collaborations, creating feedback between peers.

5) (DA) Diffusion, dissemination and sensitizing actions (to create visibility towards society and sensitizing different social groups)
Sensitizing actions aim at increasing awareness about transdisciplinary collaboration. They can be carried out in the form of dissemination actions (actions for increasing sensibility of different spheres regarding transdisciplinary collaboration).

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2 There are associations that are difficult to classify in a definitive way. For such cases, it is necessary to add more specific criteria.

6) (AIS) Actions to create an interaction structure
The interaction structure for transdisciplinary collaboration can be better realized within an institutional space from which all kinds of actions can be coordinated. This space can take form as an Observatory for Networked Science, Engineering, Art and Design. The aim is to enable agents that support transdisciplinary approaches to be in positions of power in decision-making processes. This can be achieved by complementing the network of SEAD (The Network for Science, Engineering, Art and Design) with an International Observatory for NSEAD Knowledge, to fully protect transdisciplinary collaboration.

SEAD Observatory for Networked Science, Engineering, Art and Design should be able to plan, coordinate, implement and manage all aspects of transdisciplinary collaborations. The Observatory would be supported by social network and social media platforms (transmedia approach), and coordinate the implementation of all kinds of actions (AR, NA, EA, ARS, DA). The objectives of the SEAD Network Observatory can be:

(1) To situate NSEAD transdisciplinary collaboration in the main political objectives and institutional guideless of research at any level in order to accelerate the development of sustainable, innovative and inclusive transdisciplinary knowledge in society;

(2) To foster, implement and look for funding to network knowledge and collaboration in the NSEAD transdisciplinary field. The NSEAD Observatory can be supported in a network of observatories such as European NSEAD Observatory, National NSEAD Observatories. These observatories can also be created at lower levels;

(3) To overcome hurdles in the development of an transdisciplinary knowledge Society;

(4) To foster interoperability of solutions across countries; to treat transdisciplinary Knowledge on global and local scales;

(5) To generate awareness in different stakeholders about the research and knowledge sector in order to mobilize the needed financial and human resources to carry out actions;

(6) Stimulation actions for transdisciplinary research: Promote annual research grants forresearcher groups with the requirement of the participation of at least 2 fields collaborating.

Each action must be described in relation to the scale of the problem addressed, the opportunity that it opens, the obstacles that can be found and the kind of stakeholders involved.

Opportunities and obstacles are identified according to different spheres of interaction: (1) on the scale of face-to-face interactions FFI (such as linguistic opportunities and problems, crosscommunications misunderstandings, emotions and insights, etc.);

(2) on the scale of transdisciplinary power synergies, struggles and competitions such as those that belong to authority and power elites inside each discipline (interest groups IG);

(3) on the scale of institutional educational and research structures –ERS- that are discipline-based and can be seen as structures for new opportunities or threatens to any kind of transdisciplinary action;

(4) on the scale of the social paradigm that is common in public political-administrative systems –PPAS- of funding at different levels like national, regional, European or international that are not adapted to transdisciplinary action. For instance, it is considered appropriate that a scholar follows a unique lineal disciplinary path during her/his academic trajectory and any break in this lineal path needs to be justified so that the carrier is considered adequate to academy, which reflects a Cartesian mode of thinking about academia and constitutes an obstacle for transdisciplinary fluidity. The following chart translates the elements taken from Theory of Action to structure the actions suggested to improve transdisciplinary collaboration.

Apart from these 4 spheres of interaction identified in this chart, we include activities to be carried out within the interest groups NSEAD and NSEAD Observatory (to be created). Both are interest groups that can house different interaction spheres and therefore they appear at a different level.

Table of suggested actions

1) (AR) Actions for the increasing of resources (including advocating)				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Transdisciplinary funding research programmes	Global, National, Regional and local; Continuous	To channel more access to funding, human and technological resources to collaboration across disciplinary borders	Resistance from funding institutions that still do not accept transdisciplinary approaches in research	FFI, IG, ERS, PPAS
Creation of politically	International, National,	These quotas should guaranty that a particular part of public budgets to	Resistance from funding	FFI, IG, ERS, PPAS

2) (NA) Actions to support networking: engagement, participation and networking actions				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Technical support Development of an online platform and system to support networking activities	Global accessibility Sustained by networked institutions	To develop an online platform and system to support networking activities, as an innovation ecosystem, an environment for social innovation, making full use of the Web 2.0, hybrid ontologies and the Internet of Things. Offer online support and visibility to transdisciplinary projects. Networks knowledge. Contact between peers	Maintenance sustainability Who pays for the service	FF, IG, ERS, PPAS

corrected Minimum Quotas for transdisciplinary Research	Regional	research, are oriented to the funding of NSEAD transdisciplinar research in the framework of networked knowledge. The effectiveness of these quotas will be followed-up by NSEAD Observatory.	institutions that still do not accept transdisciplinary approaches in research and from PPAS	Observatory NSEAD
Funding grant actions for transdisciplinary research	Global, National, Regional and local Continuous	Promote annual research grants for researcher groups with the requirement of the participation of at least 2 fields collaborating	Resistance from funding institutions to accept transdisciplinary research	IG, ERS, PPAS
Funding prize actions for transdisciplinary research	Global, National, Regional and local; Continuous	Promote periodical research prizes for researcher groups with the requirement of the participation of at least 2 fields collaborating. To create the space for a Nobel Prize section or Principe de Asturias section, for collaboration across disciplines)	Resistance from PPAS	FFI, IG, ERS, PPAS-Institutions linked to Nobel Prize and Prince of Asturias
Visibility actions	Global, National, Regional and local; Continuous	To make visible the results of transdisciplinary collaborations by using social network and social media platforms (trans-media approach), developing online and onsite workshops and conferences	Lack of support from institutions with resistance to fund transdisciplinary research	FF, IG, ERS, PPAS, NSEAD Observatory
Integration actions	Global, National, Regional and local; Continuous	To inscribe transdisciplinary research in all phases of decision making process of funding allotments	Lack of support from scientific politics at national, regional and local levels	FF, IG, ERS, PPAS, NSEAD Observatory

Creation of synergies with external partners and among observatories. Integration and fostering of knowledge sharing	Global, National, Regional and Local; Continuous	Creation of synergies with existing projects for the sustainability of the SEAD Network and Observatory and to intensify the networking processes with other initiatives such as Living Labs.[3] Sharing of best practices, finding partners, sharing of human and technological resources. To create synergies between NSEAD and a network of Observatories, particularly in areas like education, government, funding and administration structures	Lack of trust; lack of a common language	FFI, IG, ERS, PPAS
Creation of Research HotSpots	Global, National, Regional and Local Continuous	To foster interaction with research problems from other disciplines, other researchers and institutions. Research HotSpots would be the core around which researchers gather to search and offer collaboration	Lack of support from funding institutions	IG, ERS, PPAS
Matching around research problems	Global, National, Regional and Local; Continuous	To open a system in the network to match interests around complex research problems (that need the contribution from different disciplines). NSEAD Observatory would offer a service from the researchers' point of view. That means to offer a tool for interactivity and a bottom-up approach to information (inclusiveness) that can help researchers to plan their activities and participate in knowledge creation in the Web. Develop the network with extensive training and transdisciplinary seminars, forums and conferences	Lack of a common language to be able to dialog; lack of transdisciplinary protocols for sharing; lack of trust	Actions scope: FFI, IG, ERS, PPAS

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[3] Possible examples are (1) Innocentive (http://www.innocentive.com/), a platform for transdisciplinary collaboration and innovation; Fundation Garum (http://garumfundatio.org/redes/), an institution in the Basque Country that supports the creation of networks for business projects.

3) (EA) Education actions to prepare researchers to manage transdisciplinary collaboration				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Transformation of power relations and complementary actions	Global, National, Regional and Local; Continuous	To enable agents that support transdisciplinary approaches to be in positions of power in decision making processes Transdisciplinary research should	Lack of political support or interest; lack of funding; lack of peer-to-peer support	FFI, IG, ERS, PPAS
		be integrated in all phases of the decision making process for funding allotments		
Education actions	Global, European, Regional and Local; Continuous	To prepare researchers to manage transdisciplinary collaboration (development of academic and research methodologies to integrate different fields in research work, didactic guidelines for best practices) by using social network and social media tools and (transmedia approach), and developing online and onsite preparation workshops	Lack of interest on the part of researchers to change methodology; stress due to lack of a common language	FFI, IG, ERS, PPAS
Creation of methodologies to integrate different fields in research work	NSEAD	Methodologies are essential to enable dialog between disciplines to cover the lack of a common language	Peers resistance to incorporate and open space to other disciplines; language barriers	NSEAD

4) (ARS) Actions to support research (for researchers)				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Preparation of guidelines for best practices and a NSEAD Best Practices Database	NSEAD	The database will foster reflexion on results and extract periodical synthesis of best practices	Difficulties to retrieve information without the collaboration of researchers	NSEAD
Listening and follow up	Global, National, Regional and Local Continuous	To maintain a system of tracking opinion from researchers in the network. To update the cartography of researchers on the network and the results of their collaborations. Follow up in blog, social media tools	Lack of participation (need to stimulate participation)	FFI, IG, ERS, IPL
Creation of a "Best practices Database" for NSEAD	Global, National, Regional and Local; Continuous	To develop a database of transdisciplinary experiences for reflexion on results of networking knowledge and to extract serial synthesis of best practices. Transdisciplinary research should be integrated in all phases of decision making regarding funding	Lack of peer participation due to lack of trust	FFI, IG, ERS, NSEAD Network and Observatory
Creating synergies	Global, National, Regional and Local; Continuous	To create synergies between NSEAD and other institutions particularly between areas such as education, government, funding and administration structures	Need for paradigm shift to avoid resistance from institutions	FFI, IG, ERS, PPAS NSEAD Observatory

5) (DA) Diffusion, dissemination and sensitizing actions (to create visibility towards society and make sensible different spheres)				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Awareness increase actions aim at making pressure for changing policies and cosmovision	Global, National, Regional and Local; Continuous	To increase awareness about transdisciplinary collaboration using social network and media tools and (trans-media approach) and developing online and onsite workshops and campaigns	Lack of interest	IG, ERS, PPAS, NSEAD Observatory
Diffusion actions	Global, National, Regional and Local; Continuous	To increase awareness about transdisciplinary collaboration by publications, on paper, on Internet, in video regarding science and art	Lack of funding for publications, video documental films, etc.	Actions scope: FFI, IG, ERS, PPAS, NSEAD and Observatory

6) (AIS) Actions to create an interaction structure				
Type	**Temporal and Spatial Scale**	**Opportunity**	**Obstacle to action implemention**	**Sphere of interaction**
Creation of the NSEAD Observatory to complement SEAD Network	Global, European, Regional and Local Continuous	General institutional coordination of all kinds of actions of NSEAD to fully protect interdisciplinary collaboration and assure the attainment of NSEAD's objectives	Lack of sensibility and resistance of institutions to organize a network due to fixed paradigms	IG, ERS

Conclusions

The aim of this white paper is to offer a tridimensional stakeholder-centred matrix in which 6 kinds of transdisciplinary actions are situated according to 4 stakeholders' scales articulated around 4 spheres of interaction in order to explore opportunities and obstacles of each action.

The matrix opens the possibility to classify transdisciplinary action in a grid of 96 possible situations that can be useful for analysing how transdisciplinary action is being achieved and to plan the future action that needs to be developed by each stakeholder within the scope of their aims, possibilities and responsibilities to produce a qualitative change in transdisciplinary practices.

Bibliography

Foster, C. (2011) Three Colors: Coomassie Brilliant Blue, Sudan I and Somalia Yellow, Leonardo Journal (44, 1)

Fremantle, C. (2012) Reflections on Collaboration, http://www.an.co.uk/publications/topic/2228109 [2012-11-20]

Diani, M. and R. Eyerman (eds) (1992) Studying collective action, Oxford University Press, Oxford.

Jenkins, J. (1983) "Resource Mobilization, Theory and the Study of Social Movements", Annual Review of Sociology 9, pp. 527-553.

Kester, G. (2011) The One and the Many: Contemporary Collaborative Art in a Global Context, Duke University Press, Durham and London.

Klandermans, B. (1997) The Social Psychology of Protest, Blackwell, Oxford.

Kriesi, H. (1995) "The Political Opportunity Structure of New Social Movements: Its Impact on their Mobilization", in J. C. Jenkins and B. Klandermans (eds) The Political of Social Protest: Comparative Perspective on States and Social Movements, UCL Press, London.

Kluszczynski, R. W. (Ed) (2012) Towards the Third Culture. The Co-existence of Art, Science And Technology, Laznia Center for Contemporary Art, Laznia.

McAdam, D. (1982) Political Process and the Development of Black Insurgency, 1930-1970, The University of Chicago Press, Chicago.

McAdam, D.; Tarrow, S. and Charles Tilly (2001) Dynamics of Contention, Cambridge University Press, Cambridge.

McCarthy I. D. and M. N. Zald (1977) "Resource Mobilization and Social Movements: A Partial Theory", American Journal of Sociology 82, pp. 1212-1241.

Melucci, A. (1995) "The Process of Collective Identity", H. Johnston, H. and B. Klandermans (eds) Social Movements and Culture, UCL Press, London, pp. 41-63.

Nowotny, H. (2009) "Frontier Research in the Social Sciences and Humanities: What does it Mean, What Can it Mean?", Humanities and Social Sciences: Intersections and Joined Paradigms, ISSC-ICPHS workshop,

Bergen 11 May 2009, http://helga-nowotny.eu/ [last consulted 2012-11-20]

Nowotny, H. (2006) The potential of transdisciplinarity, http://helga-nowotny.eu/texts.php [last consulted 2012-11-20]

Ostrom, E. (2011) "Guest Introduction. Grassroots Economic Organizing", (GEO) Newsletter, Volume 2, Issue 9, http://geo.coop/node/647 [last consulted 2013-01-2]

Repko, A. (2008) Transdisciplinary Research: Process and Theory, Sage, Los Angeles, London, New Delhi, Singapore.

Smelser, N. J. (1963) The Theory of Collective Behavior, Free press, New York.

Tarrow, S. (1989) Democracy and Disorder: Protest and Politics in Italy 1965-1975, Clarendon Press, Oxford.

Tarrow, S. (1994, 1998) Power in Movement: Social Movements, Collective Action and Politics, Cambridge University Press, Cambridge.

Tejerina, B. (2010) La sociedad imaginada. Movimientos sociales y cambio cultural en España, Trotta, Madrid.

Tilly, C. (1978) *From Mobilization to Revolution*, Addison Wesley, Reading.

Turner, R. H.; Killian (1957, 1987) *Collective Behavior*, Prentice-Hall, Englewood Cliffs (NJ)

Zald, M. N. and J. M. McCarthy (1987) *Social Movements in an Organizational Society: Collective Essays*, Transaction publishers, New Brunswick (NJ)

Towards a Taxonomy of the Challenges Within Typologies of Collaborations Between Art – Design – Engineering – Science – Humanities – A Practical Guide

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Abstract

Collaborations between Art - Design - Engineering - Science – Humanities, have a tendency to look grand on paper, appear logical to the mind, but in reality are far from easy to achieve. What are the secrets to successful collaborations?

With this SEAD White Paper we propose to provide a number of suggested actions towards a taxonomy of challenges involved with different typologies of collaborations between Art - Design - Engineering - Science – Humanities. In order to do this we put out a call to artists, scientists, engineers and designers, who requested to share their expertise by elaborating on key aspects of failure and success within their experiences of collaborations. This paper has been developed in such a way that it forms a ready-to-use practical guideline for new collaborators in the field of art, design, engineering, science and the humanities.

To keep a clear overview general observations were written into a set of suggestions supported with examples, such as theoretical argumentation and referential material, which are placed in the footnotes. As well as a list of challenges, questions and comments. Advisors and contributors were asked to supplement the articles with examples from practice and theory. By mapping issues within different typologies of collaborations, new collaborators may self-identify into roles and responsibilities and construct achievable aims and results.

We realize that in rapidly emerging new areas of practice, terminologies and taxonomies also evolve rapidly; this in itself is a record of how collaborations lead to new trans-disciplinary or inter-disciplinary forms. Thus by understanding the complexity of problematic issues that surround such collaborations we hope to develop a working group of collaborators to begin to build an educational tool to be used as a practical guide by those who aspire to engage in such collaborations.

In this white paper we identify suggestions concerning the developing of useful taxonomies that clarify the variety of situations, obstacles and opportunities, to facilitate Science and Engineering

to Artistic and Design based works and theories and the scope of the Humanities and their varied collaborations.

1) Motivations We suggest that for each collaboration a meta-value is written for the motivation to collaborate that stands separately from the motivations, aims and objectives of the project in which one collaborates. We suggest to further define a main motivation and a set of flexible sub-motivations.

Example: Collaboration introduces to alternative ways of thinking and perceiving. It leads to unconventional combinations of skills and talents. It stimulates novel methods of investigation, developmental structures, processes and techniques. It creates new analogies, observational skills, perspectives and patterns. Collaborations lead to a potential of new discoveries and intellectual property.[1]

Example: Perhaps with each project the motivation is to develop new knowledge. What this 'new knowledge' actually is, and how one will obtain it, depends on the experience of each collaborator, one's discipline and the methods of one's field. For this one needs to be open to what different fields consider as new knowledge. Knowledge not only being objective, but also subjective. Knowledge that is not necessarily reproducible.

Each collaboration should define the sub-categories of motivations separately based on the institutes and individuals involved.

Example: Sub-motivations may be to work with new creative expressions or to find new forms of (social) communication with the public for instance new visualization tools for complex scientific phenomena, such as big data. New ways of finding empathy and engagement with the material is as important as raw knowledge. This can be the role of artists, who offer new creative ways of approaching problem-solving, and who also can reconfigure scientific conventions for methods of documentation and recording so that the information itself is more compelling and/or more accessible, both to scientists and the general public.

Challenges: Be aware of the motivations of the other. It is entirely possible to have differing motives and alternative aims and objectives, even while working on the same project, but it is important to be able to put things into an appropriate context. This means that it is possible that where one outcome is considered a success, while another is not.

Questions: What would you consider as a successful result? How would you measure or capture that? The metrics of success in science are quite different from the metrics of success in art. Should you define new ones? What do you consider as a novel method? A novel object? A novel discourse? What skills would you like to learn? [2]

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1 This summary is based on the reflections collected on a blog by Roger Malina in which he includes observations from The Wellcome Trust, and Root Bernstein http://malina.diatrope.com/2010/08/29/what-are-the-different-types-of-art-science-collaboration/ (last viewed Nov 14th, 2012)

2 In 2008 *The Museum of Modern Art (MoMA)* presented the exhibition *Design and The Elastic Mind* that showcased a history of how science has influenced art and how art has influenced science in particular in the areas of mobility, nanotechnology and

Comments: The motivations of each collaborator need to be clear, for yourself and for the other. Do not raise expectations to an unrealistic level, collaborating with disciplines is difficult. If you reach only 30% of what you set out to do, you have made significant progress.

2) Method and Methodology We suggest that all collaborations create a common departure for assessment and evaluation of process and results by mapping preferred methods, methodology, or methodologies. We suggest to be open to all forms of departure points.

Interdisciplinary collaborations have a high probability to fail when they stay on the level 'wouldn't it be fun if...'. The sharing of ideologies may form a 'base for valuable innovation, production, distribution and socio-cultural consumption potentials'. [3] But in order to succeed collaborators need to be able to access results and evaluations. [4]

Example: One method to finding a common point of departure for assessment and evaluation of process and results is the formulation of answers to the following questions:

What do you want to achieve? This in essence comes down to formulating a description of aims and objectives and a research question and or problem statement.

Why is what you want to achieve important and for who? This articulates the urgency and the significance of what you hope to do.

Who else has been doing similar things? This positions the project in related fields.
How do you want to achieve the project? Which methods will you be using to achieve the project?

How will you analyze and or present your project? Which methods will you be using to share your project or put the project in a wider context?

How will you monitor progress? Which type of validation (quality control) will be performed?

Challenges: The challenge in using these starting points is to be open and flexible. To be aware of how the different methods can be combined in the formation of a creative research methodology that respects all disciplines.

Example: Let's look at the question: How to make a person happy? In all disciplines this is a valid departure point. However, the methods used to answer this question are very different. An

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electronics. Visiting such exhibitions may inspire your motivations.
http://www.moma.org/interactives/exhibitions/2008/elasticmind/ (last viewed Nov 14, 2012)

3 Jill Scott, *Artists-In-Labs, Processes Of Inquiry*, Springer Verlag/Wien, 2006, p. 24

4 Ben Peperkamp, Gosuin van Heeswijk, Erwin Roebroeks: ASE: Arts & Sciences, Haalbaarheidsonderzoek & aanbevelingen, Eindhoven p.p. 15-16 found on http://www.alice-eindhoven.nl/2009/09/artscience-centre-eindhoven/ (last viewed, Nov 14[th], 2012) In this they refer to statements by Robert Zwijnenberg and Joep Huiskamp

artist might choose to begin with a very iconic starting point: the study of a balloon. A simple tool considered to bring happiness.

At first glance this might not be interesting for another discipline, until that study of the balloon becomes for instance an attempt to make the smallest balloon possible and the wish is to insert it into a human body. What does it mean if that balloon holds a 'happy acid' face and a yellow balloon is inserted with a needle. What does it mean when the material of that balloon actual contains 'happiness inducing' chemicals. How small can we go? Can a balloon still be yellow when it is nano? The important thing is to allow room for imagination, and not be bound by limitations of existing ideas.

Questions: What questions are you not allowed to ask yourself within your discipline? What methods are you not allowed (or not willing) to use? Why? What are the consequences? Are you able to think outside the box? Are you willing to throw the box away?

Comments: The main thing to be aware of is that one cannot judge any starting point a priori. One needs to understand that what is considered as a valid answer and or question depends on the discipline and field. This is important to protect the field, yet it also limits a field. Collaborators need to be aware of, and be prepared to use, insights that were not anticipated. This implies a willingness to diverge and embrace tangents.[5] as well as a transgression of what are usually considered as disciplinary boundaries.

Financial Issues: Anyone searching for funds is confronted with the need to be able to sketch answers to such questions. Depending on where you are applying and for what, the narrative may change to fit requirements of a funding institution. This requires the ability to view an application through different policies. The methods you bring to the foreground in grant applications can influence decisions. Transdisciplinary collaborations are difficult to get funded and maintain. The collaborators need to be aware of the incentive and reward structure in the collaborators area. This may be different from their own. That way collaborators can report back on what was achieved. Here too time can be a big issue. You want to get started but you have to deal with all sorts of administrative issues that can cause many unexpected delays. The more people involved – the more a collaboration will cost.

(Differing) expectations: Mapping individual expectations in advance will help avoid misunderstandings and disappointments.

Credits: When collaborating it is crucial to respect all contributions. The more complex a collaboration becomes the more important it is to keep track of involvement. Make sure that everyone is credited appropriately. Think about how the film industry structures and credits complex collaborations.

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5 Ben Peperkamp, Gosuin van Heeswijk, Erwin Roebroeks: ASE: Arts & Sciences, Haalbaarheidsonderzoek & aanbevelingen, Eindhoven p.16

Time: a collaboration can accelerate a process, but more likely it may also decelerate a process. Are you using tools like a time able, flow chart or a Gantt chart? When you determine a structure you will find a way to organize this, this does not need to be a linear process. Often calls for collaboration are put out that need to take place in a 3 month timeline. This is hardly enough time for an individual to develop a project. Anyone planning a collaboration needs to take realistic planning into account.

Locations: While some people work only behind a computer, many need a studio workspace. When such a space is not provided – collaborations that aim to make use of different methods can become problematic. Respect the needs of the collaborators you invite.

Ethical issues: A very real issue within collaborations is the issue of ethics. Many methods, in particular where human subjects are involved, might be considered unethical. Sometimes special permission will be needed. This might also require higher costs. Think about issues of fire safety. Where one might turn a blind eye in a project space for a one time execution of a flammable work, an institute has to be more strict. Make sure such issues do not surprise you at a last moment.[6]

3) Knowledge Transfer and Dissemination We suggest paying particular attention to moments and methods of knowledge transfer and to devise a clear plan of action for knowledge transfer and dissemination.

Example: A nice example of a particular form of knowledge transfer is given by Jill Scott in her essay Suggested Transdisciplinary Discourses For More ART_SCI Collaborations in which she explains how in trans-disciplinary collaborations knowledge transfer is often situated, meaning it is embedded in language, culture, tradition as well as methods. It is, as she elaborates, entwined with reflection and interpretation for instance with metaphors, contextual immersion and relational creativity. She gives the example of the differences in impact on the general public between a generalized metaphor already embedded in everyday language and a poetically mind-shifting metaphor, explaining that the embedded knowledge might move between dimensional associations, spatial orientation as well as the ontology of a metaphor (abstract vs. concrete texture). For instance, by breaking down archetypical metaphors such as 'hard' (difficult) science and 'soft' (easy) science could break old, biased, often gender based, hierarchies.[7]

Challenges:

Objectives: When two or more disciplines are collaborating, knowledge transfer happens on more than one level. It is important to respect all levels of knowledge transfer. Or to prioritize depending on one's objectives. It is important to note here that personal research is quite different from a double-blind clinical trial; something that differentiates art and science. [8]

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6 An interesting project on ethics may be found here: www.artscienceethics.com (last viewed, 14 Nov, 2012)

7 Jill Scott, Ibid p.p. 24-26.

8 McGuire, A.L., & Lupski, J.R. (2010). Personal genome research: what should the participant be told? *Trends in Genet*ics, 26: p.p. 199-201.

Presentation: Artistic insights and knowledge might be best disseminated in an exhibition as well as a publications, lectures, and presentations. Different presentation methods present requirements. It is important to take the requirements of each field into account. Presenting works in an exhibition hold different requirements than presenting results in a lecture or publication. How will the presentation methods be designed? Will there be a curator? A graphic designer? A mediator? An installation consultant?

Documentation: How to share results and with whom? What medium will work most effectively? Does one describe results with text? And if yes, with which style? with drawings? photographs? A YouTube mini documentary video?

References: Methods of reference are common practice within the sciences, within art this can be a delicate issue. Artists are used to sharing their influences, but are not trained in being and or remembering sources. Artists have a tendency to be protective of their inspirational sources as art is often criticized if it resembles too much the work of another. Where as in science this is considered discourse and a blessing to find.

Failure: In science a project might fail, without it being a scientific failure. Where in science an outcome might be a disappointment, it is not necessarily damaging to a career. In the arts, failure is feared more often than not. In spite that the artist is often told not to fear failure, the artist is not accustomed to show failure to the general public, unless that is an integral part of the art practice. This might cause tension and or confusion within a collaboration.

PR and Communication: The approaches for PR and Communication can be very different for each field. This needs to be discussed. In science certain issues would be considered prudent to not share with a general public, where in art scandal and danger might bring an edge to a work in such a way that it contributes to the success of the work.

Questions: What are the identifiable results of the collaboration? How are the results distributed in the different fields? How do these results relate to trends in the art world? How do the results fit within a discipline's discourse? What role does an institute play? What type of institutes are involved? Who is your audience? What do you expect from them? Is the collaboration a two-way benefit or can only one side benefit from the collaboration?

Comments:

Brainstorming: Brainstorming can be useful method for finding common ground. When brainstorming, depending on how many individuals are involved, it is useful to appoint an experienced mediator, a facilitator, and someone who documents. When brainstorming one needs to be aware of levels of listening vs. talking [9]

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9 http://www.slideshare.net/leisa/collaboration-techniques-that-really-work-presentation

Rules: to find common ground it can be useful to do exercises that define the parameters of participation. This can be taken to a creative level where the rules become: 'there must always be a sheep involved' – 'it must always happen at night'. One might also use socratic dialogue methods.

Institutions: it is important to determine what role institutions play in the process of the knowledge transfer in terms of reaching an audience, as well as knowledge conservation.

Audience: Who is your target audience? The general public? Professionals? Where science might aim to convey the understanding of an audience as accurate as possible, in the arts, the responsibility of understanding is often left to the devise of the audience.

Critics and Peers: It is important to think about how you involve critics and peers in your process, and to think about their role in the dissemination of knowledge.

Educational institutions should think about how to educate innovative collaborations, and help understand the different forms of knowledge transfer. They need to find a way to facilitate and stimulate the skills that are exchanged in collaborations within their curricula – for this to happen, specialist attitudes need to be flexible.[10] One also must not underestimate the role an educational institution may play in the development, dissemination and preservation of developed knowledge. Investigate this.

4) Definitions and Generalizations We suggest that collaborations define their respective disciplines through generalized descriptions in their own words, and to identify the presence of generalizations in everyday language as well as generalizations in different fields of study. One might not think it, but in an over-specialized world generalization is important – without generalization we would not have an overview, it would be more difficult to communicate, or lead. It is important to know when it is functional and when is it not.

Example: Collaborations between Art - Design - Engineering - Science – Humanities are often generalized as SCI-ART collaborations in which 'The Arts' subdivided into: Design, Dance, Theatre, Art, Fashion, Fine Art, in which divisions are made between Autonomous Art and Applied Art. And 'The Sciences' are subdivided into into the 'hard' and 'soft' sciences: 'Hard' being: technology, engineering, physics, chemistry, biology and 'soft' being disciplines such as philosophy, psychology, sociology. What if these "hard" categories were to be treated as "fuzzy" categories with flexible boundaries?

Example: Other countries, such as The Netherlands, make divisions as follows: Alpha sciences as the study of the products of human action and behavior: (art) history, linguistics, literature, music, philosophy. Alpha tends to use methods in which well-argued interpretation is autonomous. Beta sciences as study of non-human nature: physics, biology, maths, and technology. Beta sciences tend to use causal methods. Gamma sciences as the study of human

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10 Jill Scott, Ibid. p. 24

action and behavior: psychology, sociology, law, economy and some philosophies. Gamma tends to use both[11].

Example: As an artist I am interested in: the creation of meaning, perspective shifts, expression and aesthetics, as manifested in associations, materials, lines, colors, volumes, movements, behaviors, structures and experiences. Why? To make us think, to make us aware, to make us understand, to make us experience, to entertain.

As a designer I am interested in: shifts of functionality, efficiency, practicality, aesthetics and usability of objects and materials, as manifested in objects, structures, behavior, experiences, lines, volumes, colors, maths, and patterns. Why? To make things better, depending on what needs to be made better and what is considered as better.

As an engineer I am interested in: how things work in order to make things that work, as manifested in mechanics, physics, structures, biology, chemistry, software and hardware. Why? To create things that work, depending on what needs to work and how it needs to work.

As a scientist I am interested in: finding, structuring and organizing knowledge in the form of testable explanations, as manifested in the maths of chemistry, physics, chance, materials and patterns. Why? To understand, to create, to predict, to build, to think, to be aware.

The humanities are interested in: how and why humans do what they do? This is manifested in observations, experiments, research, formulation of theories and arguments. Why? Curiosity is human nature. To help us understand, to help us predict, to help us think, to help us regulate, to help us sustain, to help us create.

Challenges:

Shared Methods: drawing, observation, experimentation, and validation are methods used in all disciplines. Be aware of the differences. Observation in physics has different connotations than observations in art, be aware of differences in methods of observation, subjective observation of an eye or objective observation with numerical instruments.

Definitions: The meanings of words differ from discipline to discipline. These differences may be subtle or less subtle. Discuss meanings on a regular base. The meaning of 'embodied' in Artificial Intelligence is not the same as in dance[12].

Communication: the challenge here is to find the right balance, to respect all disciplines and to treat disciplines as equal, at the same time do not forget your own discipline. When learning new skills, it is easy to get carried away with the methods of another discipline. Regular communication, learn to listen, learn to be aware.

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11 ://www.uu.nl/wetfilos/bijsluiter/alphabetagamma.html (last viewed Nov 14, 2012)

12 Jill Scott, Ibid. p. 26 and p. 27

Questions: How do you define what you do? How do you define your field? What are the paradigms of your field? What are the boundaries of your field? Are you using a top-down or a bottom-up approach to generalize?

Comments: Throughout history the categorizations of science have shifted. This is not always considered as a good thing [13]. Be respectful of paradigms, but do not be afraid to shift them. Art has paradigms just as much as science does. Think about notions that art can only be made by artists or that theory is harmful to art. For each collaboration new paradigms need to be created.

5) Types of Collaborators and Collaborations We suggest to determine types of collaborators and collaborations, as they are closely linked to expectations and motivations.

One of the first things that would be good to determine is if the collaboration is multi-, inter- or trans-disciplinary. Disciplinary meaning a branch of knowledge, instruction, or learning, a field of study [14]. The differences between Multi-, Inter- and Trans- disciplinary is difficult to understand as the definitions have not yet been significantly researched and are often used intermediately in everyday language. Good explanations have been developed by health research scientist Bernard Choi and consultant Anita Pak [15]:

Multidisciplinary: draws on knowledge from different disciplines but stays within the boundaries of those fields. Is like a salad bowl (such as a vegetable platter or mixed salad, in which the ingredients remain intact and clearly distinguishable). Additive, 2 + 2 = 4

Inter-disciplinary: analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole. Is like a melting pot (such as a fondue or stew, in which the ingredients are only partially distinguishable). Interactive, 2 + 2 = 5

Transdisciplinary: integrates different disciplines and in so doing transcends each of their traditional boundaries. Is like a cake (in which the ingredients are no longer distinguishable, and the final product is of a different kind from the initial ingredients). Holistic, 2 + 2 = yellow

Example:

Paradisciplinary: Unlike inter-, multi-, cross- and transdisciplinary collaborations, which define various types of interactions among a group of (at least two) individuals working together on a common project (e.g. an artist and a scientist), paradisciplinarity applies to a single individual practicing two disciplines at the same time.

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13 http://blogs.scientificamerican.com/literally-psyched/2012/08/10/humanities-arent-a-science-stop-treating-them-like-one/

14 Bernard C.K. Choi, Anita W.P. Pak, 'Multidisciplinarity, Interdisciplinarity And Transdisciplinarity In Health Research, Services, Education And Policy: 1. Definitions, Objectives, And Evidence Of Effectiveness', Clin Invest Med, vol 29, no 6, December 2006 p.p. 359-360

15 Bernard C.K. Choi, Anita W.P. Pak, Ibid. p. 352

Two conditions are thus required for any given practice to be defined as paradisciplinary:

i) Parallelism – the two disciplines must be performed in parallel by the same individual, in a synchronous fashion (a neurobiologist who is also choreographer clearly meets this criterion; a choreographer who changed career to become a neurobiologist does not)

ii) Symmetry – the importance (involvement) of each disciplinary practice must be relatively symmetrical in the individual's curriculum (a composer who publishes scientific papers in acoustics and also performs musical pieces in concert halls meets this second criterion; a physicist who publishes in scientific journal and also enjoys playing the piano at home does not)[16]

We encourage each project to define their own definitions and types of collaborators.

Example:

5 Types of Participatory Collaboration between art students and university students[** 17]
1. A university student interested to get closer to art with the interest of gaining depth and new perspective in relation to their own discipline. Participating observer.

2. A university student who is interested in the integration of artistic methods without aspiration of making art. Integrating artistic methods as an enrichment of academic methodologies. Art without the artist. Active observer, for instance involved with methods of re-enactment.

3. A hybrid student, trained in one or more disciplines. One who seeks new forms of knowledge production combining artistic and academic methods aiming for the highest achievements in both methodologies. This may also be a team of two or more people type 2 and 3.

4. An art student who wants to get closer to the theories that are related to his work. Aims for high artistic achievement. Knowledge development is Secondary.

5. An art student who wants to get inspired by academic theories. To get closer to science. Theories are applied to suit the artist and are not tested or analyzed for truth.
** please note that in The Netherlands universities are separated from art schools

We encourage each project to design and work with their own metaphors.

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16 As mentioned by François-Joseph Lapointe in his SEAD White Paper: http://seadnetwork.wordpress.com/white-paper-abstracts/final-white-papers/how-i-became-an-artscientist-a-tale-of-paradisciplinarity/ (last viewed, Nov 16th, 2012)
17 This description was born from observations within the hounours programme Art and Research, a collaboration between the University of Amsterdam and The Gerrit Rietveld Academie.

Example: For instance one might refer to collaborations as they are manifested in nature and described by biology as: mutualistic collaboration (+/+), competition (-/-), parasitism (+/-), Neutralism (0/0), Commensalism (0/+) [18]

Challenges: The more people are involved the more difficult it may become to reach a common vision.

Questions: What type of collaborator are you? What is your role? Will you function as advisor? passive or active observer? Facilitator? Actor?, Teacher? Co-creator? Co-author? What are your expectations? Who is leading the project? Are there more than one leader? How is your collaboration structured?

Comments:
Vision: Creative endeavors often require visionary approaches. Is the project led by one vision(ary)? Or more?

Responsibilities: To avoid disappointment or confusion it is important to clarify who is considered responsible for what, and when, but also to allow for flexibility within these responsibilities.

Attitudes: Respect for the collaborators field/interests and differences to one's own has to be paramount. Do not consider your discipline as intellectually superior. Be ready to investigate the methods and methodologies of different disciplines [19]. Be ready to learn new skills. Respect the accumulated knowledge of each discipline as well as the associated means of expressing it. Transdisciplinary collaborations are a catalyst to innovation. You truly cannot predict what you get.

Commitment: Individuals should be clear about what their commitment can be for the project.

International: When collaborating in an international context, one might encounter miscommunication due to language difficulties, where things may 'get lost in translation' or cultural differences. These may involve banal issues such as time punctuality or directness versus circling around an issue during dialogue.

Summary

ONE SUGGESTED ACTION:

Create a comprehensive practical guide that builds towards a taxonomy of the challenges within typologies of collaborations between Art - Design - Engineering - Science – Humanities starting from and adding to the issues touched upon in this paper in order to facilitate successful collaboration: Motivations, Method and Methodology, Knowledge Transfer and Dissemination,

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18 With thanks to François-Joseph Lapointe
19 Jill Scott, Ibid p. 26

Definitions and Generalizations, Types of Collaborators and Collaborations. Dealing with issues such as structure, location, funding, planning, communication, commitment, time, ethics and attitudes.

Obstacle/opportunity: centralized practical knowledge about multi-, inter, and trans- disciplinary collaboration, in particular with Art - Design - Engineering - Science – Humanities collaborations, is insufficiently documented and or collected. Many individual projects have made reports of their findings. This is an opportunity to create a collection of guidelines that in a low threshold practical formation, may function as an international handbook that can be used as a tool for future collaboration projects.

Stakeholders: for all (new) collaborators and educators of multi, inter, and transdisciplinary collaborations, as well for those who initiate, facilitate and or fund such projects.

Building an Interdisciplinary Research Team

Coordinator: Sile O'Modhrain, School of Music, Theatre and Dance, University of Michigan.

Abstract

Universities, Grant-awarding bodies and industry increasingly emphasize the value of Interdisciplinary Research and strive to build infrastructure for establishing interdisciplinary research teams. However, the assumption that simply bringing together a group of talented and skilled researchers who are enthusiastic about a given project is sufficient to deliver innovative research is somewhat naive and can often result in an experience which is disappointing for both the members of the team and the project's stakeholders. Drawing on almost 20 years of both working within and directing interdisciplinary research teams in the fields of haptic interaction and digital musical instrument design, the author suggests that, by giving some thought to the balance and distribution of skills and interests of team members at the point of recruitment, and by gaining a better understanding of the process of development that must take place within the team during the lifetime of a research project, the quality of the interdisciplinary research experience can be greatly improved both for individual team members and for the wider community of stakeholders in the project.

Introduction

For the past 20 years or so, both academia and industry have placed much emphasis on the importance of interdisciplinary research, research that draws upon a broad range of skills and interests in the service of a common goal. Whether through the mechanism of collaborative projects in the classroom, through collaborative grants, or through the hiring and resourcing policies of academic and industrial laboratories, such teams are now a mainstay of todays research landscape [1, 2, 3?].

There is a growing body of literature that discusses the value of interdisciplinary research from the perspectives of multiple stakeholders including research institutions [Dodson et al, 2010], funding bodies [National Science Foundation 2012, National Academies 2005]. This is paralleled by a body of work on team building for interdisciplinary projects much of which emphasizes the need to manage the expectations of the many stakeholders that might be involved including academic and industrial partners and, of course, the researchers themselves [Dodson et al, 2010, Lyall et al, 2011]. This paper does not seek to add to their findings, but rather to discuss, from a very practical perspective, some measures that can be considered when building and managing an interdisciplinary research team from the point of hiring team members, through to the point of advising researchers on their next career steps. The suggestions here stem from the author's own experience in being part of and directing interdisciplinary teams which have combined the skills of artists, scientists and engineers to build prototypes of human-computer interface devices (HIDS) for haptic and tactile interaction, mobile interaction and for digital musical instruments..

Hiring Researchers for an Interdisciplinary Team

Given that the output from any team will depend on the skills of its individual members, how should one go about the process of picking researchers for an interdisciplinary team? The most obvious answer to this question is to pick people with the skills that you need in order to accomplish the goals of the project. And certainly doing so should ensure a successful outcome. But is this enough? The answer is that it depends on the nature of the work involved. Where the goal of the project is highly specified, such as staging an opera, there will be a set of very clearly defined skills that are required and very clearly defined roles for each team member. However, where the goal for a team is more open, i.e. for research that is at a more exploratory stage, the skills required may be much less obvious and the roles of individual team members as yet unspecified. While both cases represent teams engaged in interdisciplinary work, and while both may involve research, it is worth considering the kinds of team members that might be appropriate in each case. For the opera, research might focus on historical accuracy for costumes, sets, musical performance, and so on. For the most part, this work would be done by a few key team members and used to shape the overall production. Skills are specific to individuals and are reflected in their roles in the overall production team.

In the second case, however, skills and roles are much more fluid. At the outset of a research project certain core skills may be required but these will need to be augmented by additional skills as the nature of the project emerges. For example, in designing an interface device, it is often possible to implement functions both in software and in hardware. At some point, a decision will be made as to which rout will be taken and additional expertise may be required to support this decision.

The question then becomes, how can you hire team members who have sufficient skill to create initial working prototypes but sufficiently broad interests and experience to identify novel approaches to solving problems. The solution proposed here is to look for team members who have deep skill in one area that is central to achieving a projects goal, but a breadth of knowledge and experience that will mesh with the knowledge and experience of other team members. So, for example, one might start out with a list of skills such as mechanical engineering, computer programming, electrical engineering, physical artifact design, etc. but one might also look for interest or experience in a creative activity such as music, film making, painting, invention, etc. that demonstrates that a researcher engages in some form of generative activity in a domain beyond their main area of focus. In the author's experience, those researchers who fail to thrive in interdisciplinary teams are highly likely to be those who start out with few interests beyond their primary research domain and little experience in generative activity of any kind. It should be noted that the opposite is also true, that those from backgrounds in Art or Music and who demonstrate some evidence of having engaged in, say, mechanical design or programming, are also likely to be more successful when participating in interdisciplinary projects. And yet, people from backgrounds in the Arts and Humanities are rarely sought out for interdisciplinary work because research leaders have historically undervalued the contribution they can make. Highlighting the skills that students with backgrounds in the arts can bring to a project, Keith Sawyer and Elizabeth Long Lingow identify the following::

"Predisposition to take risks
.. Individual and collective creativity
.. Working with emergent ideas in groups
.. Capacities of resilience
.. Ability to "push" thinking
.. Ability to support playful cultures when responding to challenges
.. Creating fluidity/interventions in routinized/rigid organizations
.. Build a practice of cultivated ambiguity
.. Transfer skills between disciplines (artistic and non-artistic)
.. Broad knowledge
.. Listens
.. Revises
.. Persuasive speaking skills
.. Has some research capacity
.. Ability to build / manage
.. Networking capacity
.. Trusts in engaged imagination
.. Willingness to fail
.. Decision-making that is an action
.. Ability to disregard dominant point of view"

(Sawyer and Long Lingo, in Reid et al 2011, PP21-22.)

The lack of appreciation, on the part of team leaders, for the value of skills and interests beyond those specified for a given position (job, Ph.D. hire, and so on) means that teams will continue to hire those like themselves leaving little opportunity for their culture to evolve toward a more interdisciplinary environment. Because students know this, they are less likely to take the risk of investing time in work of an interdisciplinary nature which they perceive as being less value to them in obtaining a strong qualification. And thus the seed is sewn for a lesser appreciation of interdisciplinary work and is reflected in the hiring strategies of this next generation of research leaders.

Proposed Solutions

To encourage interdisciplinary team work at every stage of a researcher's development from undergraduate class projects through graduate and industry research.
To educate team leaders so that they can appreciate the value of team members who can move easily between different modes of working, E.g. from creative practice to procedural methods.

In this way, it may be possible to break the cycle that currently holds back the evolution of a truly interdisciplinary research culture.

Developing an Interdisciplinary Team

There are many ways in which interdisciplinary research teams are formed. In some cases, a lead researcher is tasked with hiring new team members or with selecting members from other

parts of an organization to participate in a project. At other times, teams are formed in the process of proposal writing. In both cases, the immediate challenges are the same – to develop a shared understanding of the goals of a project and of the path that will be taken to achieve these goals. As anyone who has participated in interdisciplinary research will attest, this is often the most frustrating and time-consuming phase of the project. It is the stage where participants must establish mutual trust so that they can be freed to step outside their disciplinary carapaces and to open themselves up to the possibility that there are multiple ways of solving a problem and that other disciplinary approaches might even be more appropriate in some situations. For researchers who have invested many years of their lives (and often much of their money) in acquiring their skills and knowledge, this is a very painful process.

So what can research leaders, and indeed individual team members, do to manage this phase of team development? In the authors experience, three things need to happen during this time:

1. The development of a shared language – team members need to agree, quite literally, on the words that describe key terms and concepts that relate to the work they must complete. More importantly, they must agree on the definitions of terms and the phrasing of concepts so that everyone has a shared understanding and a means of communicating clearly with other team members. While this may seem trivial, it is incredibly important. It takes time for such shared understanding to emerge, but, in the authors experience, it is time well spent (see also Lyall et al, 2011, Chapter 4.).

2. The development of shared goals – Again, this seems trivial, but it is worth spending time making sure that all team members clearly agree on what must be achieved within the project. This is also the time to agree on which methodologies will be applied to address different sub-goals or sub-tasks as there may exist within the team different disciplinary methodologies that could be applied to a given task. It may be the case that, for open-ended projects, multiple methodologies could be explored and their results compared or combined.

3. The establishment of mutual trust – It is no secret that interdisciplinary projects stand or fall on the basis of how much individual team members trust their collaborators to be respectful and to pull their weight. Since not all team members are equal (either by virtue of their position in an organization or their stage of career), this can be a difficult process to navigate. The important thing, in the author's experience, is that a team leader should find ways to create an environment that is open and respectful, so that researchers who are less secure can develop confidence in their own abilities and can recognize that they are valued members of the group.

Proposed Solution(s)

To provide a forum where constructive critique within an interdisciplinary team is encouraged so that other approaches and methods for problem solving can be evaluated and adopted where appropriate.

To focus, particularly at the start of a project, on the development of a shared language that will facilitate communication of ideas between team members from different disciplinary backgrounds.

To allow sufficient time for these processes to unfold.

Advising Interdisciplinary Researchers

Though we rarely discuss it, the worry that many of us who introduce young researchers to interdisciplinary environments have is that they will be perceived, by their peers and by potential employers, as having had a training that is somewhat weaker or less rigorous than others who have not strayed beyond the boundaries of their subject. In short, are we setting these individuals up for failure by potentially causing them to be marginalized even within their own fields? This concern persists despite the current drive for interdisciplinary research and is fuelled by a continued perception that working outside your discipline suggests that you have failed to be successful within it. And yet, the most successful interdisciplinary research attracts the very best researchers because they are the individuals who are most capable of taking knowledge from their domain and applying it to problems outside their field.

So what steps can be taken to address this perception? On the one hand, there is a need to work with individual researchers in order to develop a strategy that addresses questions such as how and where to publish, how to write a resume and which jobs to apply for. For those going into academia, it is not too early to discuss how they will approach tenure and whether they should consider single or joint departmental appointments. Lyle et al (2011) suggest posing the following questions:

"1. Where do you want to make your contribution? (Publish within one or across several fields; create new interdisciplinary fields; lead in the development of creative solutions to a critical problem?)

2. What support and training do you need in order to achieve this?"
(Lyle et al, 2011, Chapter 5)

In parallel, there is a need to work toward changing the perceptions of those inside disciplinary silos. For publishing, it is often ones research piers that need to be challenged to recognize the value of alternative approaches to a problem. In a way, they need to go through a process that is similar to that engaged in by an interdisciplinary group at the outset of a project. The challenge is that, unless they are willing to be open to what they find on the page before them, this may never happen and the value of an interdisciplinary contribution may thus be overlooked.

With respect to career path (jobs, tenure, and so on), the challenge for the researcher is in presenting what might seem like a disparate body of work so that it reflects a clear developmental path. Here, senior faculty should be encouraged to help by ensuring that they go into faculty search and promotion committees for interdisciplinary researchers informed about recent developments in their own fields that have benefited from knowledge from another

discipline. There are many examples of outstanding work in most fields of this kind and often the obstacles facing young interdisciplinary researchers are purely those in the minds of their evaluators. Let us not forget that Artificial Intelligence and Computer Science were once interdisciplinary projects on the edges of Mathematics and Engineering.

By making funding available for senior faculty to become involved in interdisciplinary projects, and by encouraging interdisciplinary work in the class room, institutions can also do their part in changing attitudes and smoothing the career path for those who have set out on an interdisciplinary career path [University of Michigan 2012, Iowa State University 2011].

Proposed Solution(s)

Academic leaders, such as universities – to provide substantive funding that encourages faculty and research students to work across disciplinary boundaries to achieve real and tangible results.

Tenure boards – to recognize that successful interdisciplinary collaborations (and their associated publications) represent evidence of a researcher's ability to abstract their own skills and apply them to solve problems within a completely different resume that illustrates participation in interdisciplinary work is a strength and not a weakness as it again illustrates an ability to abstract skills from one domain and apply them within another.

Peers – to recognize that colleagues who participate in interdisciplinary work can contribute new and valuable findings that only become possible because of the challenges of applying knowledge to solve problems in another domain.

Summary of Suggested Actions

1: Hiring
Suggested action – Look for deep skills in an area of expertise that is required, but broad interests that reflect the nature of the work to be carried out.

2: Developing an interdisciplinary team
Suggested action: Develop an appreciation for multiple perspectives and multiple approaches to problem solving within a team. Provide a forum where constructive critique within an interdisciplinary team is encouraged so that other approaches and methods for problem solving can be evaluated and adopted where appropriate. Focus, particularly at the start of a project, on the development of a shared language that will facilitate communication of ideas between team members from different disciplines.
To allow time for these processes to evolve.

3) Advising Interdisciplinary Researchers

Suggestion – To evolve, with each team member, a path or plan for their development as an interdisciplinary researcher. Discuss with researchers the challenges involved with pursuing

interdisciplinary work so that they can make informed choices about how and where to publish and how to approach applying for jobs and gaining tenure.

To encourage senior faculty members who are involved in hiring and promotion committees for interdisciplinary researchers to be informed about work that represents best practice of integrating knowledge from other disciplines.

References

Iowa State University [2012] Presidential Initiative for Interdisciplinary Research
http://www.president.iastate.edu/12/pdf/ research Initiative092512.pdf

University of Michigan (2012) MCubed,
http://www.mcubed.umich.edu

National Academies, 2005. "Facilitating Interdisciplinary Research."
National Academy of Sciences, National Academy of Engineering, and Institute of Medicine,
        National Academy Press Washington
NSF [2012] Interdisciplinary Behavioral and Social Science Research (IBSS)
        http://www.nsf.gov/pubs/2012/nsf12614/nsf12614.htm
National Science Foundation, 2012
M.V. Dodson et al. [2010] "Perspectives on the formation of an interdisciplinary research team".
        Biochemical and Biophysical Research Communications 391PP1155–1157
C. Lyall, A. Bruce, J. Tait and L. Meagher [2011] "Interdisciplinary Research Journeys:
        Practical Strategies for Capturing Creativity". Bloomsbury Academic, 2011
T. Reid, [2012] "Art-Making and the Arts in Research Universities". University of Michigan,
        Ann Arbor, MI

The Nanoart 21 Project

Coordinator: Cris Orfescu

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Introduction

This white paper will examine the origin of NanoArt and contemporary NanoArt status, will review several Technology supported Art programs, and will report the contribution that NanoArt 21 brings as an organization which strongly encourages Science/Engineering–Art/Design collaborations. Actions to be taken in support for the NanoArt 21 organization in order to accomplish successfully its worldwide project are suggested in conclusion.

The Origin of NanoArt

The new technological moment is reflected in a new artistic discipline and movement. NanoArt is a complex artistic-scientific process comprising three major steps:

1. Creation of the nanosculpture (sculpture at atomic and molecular scales) by manipulating atoms and molecules using chemical reactions and physical processes or discovery of the nanolandscape (natural nanostructures);

2. Visualization of the nanosculpture or nanolandscape and image capture using computer-controlled advanced microscopes;

3. Artistic interpretation of the scientific images using different artistic techniques in order to convert these images in to pieces of artwork to be showcased for large audiences and to educate the public with creative images that are appealing and acceptable.[1]

NanoArt is strongly related to the visibility power which increased exponentially about 1000 years ago with the eye loop and eye lens as upgrades of the human eye, continuing in the Renaissance period with the optical microscope, and culminating in the late 1930s with the first commercial electron microscope. Orfescu suggests that NanoArt originated about the time when the electron microscope became commercially available.

"The most influential cell biologist ever" (Hopkins, 2008), George Emil Palade (1912 – 2008) could also be one of the first nanoartists in history. Palade was a Romanian cell biologist and 1974 Nobel Prize Laureate in Physiology and Medicine. He started the "George E. Palade Electron Microscopy Slide Collection" of electron microscopy images at Harvey Cushing/John Hay Whitney Medical Library at Yale University. Derived from high-resolution images, this is a valuable research tool, free for all students and scientists.[2] This collection includes some of the earliest electron micrographs taken by the collaborators of George Palade at Rockefeller University (1945-1973) and Yale (1973-1990): Marilyn Farquhar, Maya and Nicolae

Simeonescu, James Jamieson, Lucien Caro, Philip Siekevitz, John Bergeron, Japoco Meldolesi, and Sanford Palay among others.

We don't know if these scientists had the intention to create art, but they did create original scientific imagery which could be converted into or considered by some to be artworks.

Contemporary NanoArt

Contemporary NanoArt is the intentional merging of scientific and aesthetic pursuits. The study of the micro and nano worlds unveils imagery with strong artistic potential. Scientists manipulate the scientific imagery they capture and create NanoArt works. The depth and three dimensionality achieved in NanoArt distinguishes electron imaging apart from photography, in which images are created by photons (particles of light) rather than by electrons (electrically charged particles) as in NanoArt. With NanoArt, electrons penetrate deeper inside the nanostructures, generating images with more depth and a more natural 3D-look than seen in photographic images.[3]

NanoArt web exhibitions include pioneers such as Donald Eigler, Anastasios John Hart, Jack Mason, Tim Fonseca, Robert A. Freitas Jr., Joe Lertola, Cris Orfescu, to name only a few who started producing works in the early 1990s and some of them even earlier.

Nanotechnology-based art was lately supported at different Universities by their research labs with an interest in art (ex: UCLA, Northwestern University, Rice University, Georgia Tech), by scientific or engineering organizations (ex: Materials Research Society), by private companies interested in marketing their equipment and services (ex: Nikon, Hitachi) or in new product development (ex: IBM). The majority of NanoArt events initiated and sponsored by these institutions were addressed mostly to scientists and engineers who developed an interest for art and the aesthetics of the nanostructures. Most works were generated by scientists or engineers affiliated with these institutions or participating in competitions organized by these organizations. The most noticeable collaboration is between UCLA professors Victoria Vesna (artist) and James Gimzewski (nanoscientist). Their projects have been sponsored by different institutions including UCLA and the Los Angeles County Museum of Art (LACMA).[4]

Technology Supported Art Programs

Although not specifically developed for NanoArt, art and technology programs from different countries produced innovations and yielded a number of discoveries.

FutureLab was formed in 1996 as an R&D spin-off of the Ars Electronica Festival in Linz, Austria, initially to fabricate the commissioned artworks for the Festival and for the Ars Electronica Centre, a permanent museum opened in the same year. The Ars Electronica Festival, which began in 1979, is the premiere international gathering of its kind, attracting several thousand people from the electronic arts community who gather for discussion, debate, and exhibition. Supporting financially Ars is paying off economically. FutureLab has increasingly earned income through external projects with computer industry. FutureLab has also developed its own products, usually as the results of art projects, including PC-based 3D modeling

software, inexpensive VR goggles, and a projection-based worktable. FutureLab is offering its years of art experience to help solve user interaction and other design problems. However, FutureLab could never thrive, nor even exist, without Ars' base funding from the government.[5]

Two programs which disappeared during the 1990s were Interval and PARC Artist-In-Residence (PAIR) program. The idea behind Xerox's interdisciplinary Palo Alto Research Center (PARC) is simple: if you put creative people in a hothouse setting, innovation will naturally emerge. PARC's Artist-in-Residence Program (PAIR) brings artists who use new media to PARC and pairs them with researchers who often use the same media, though in different contexts. This is radically different from most corporate art programs which do not encourage collaboration between artists and research scientists. The result is both interesting art and new scientific innovations.6 Unlike at Interval where the artists were employed, PARC artists remain independent and receive stipends. While PARC artists owned the work they produced, Interval owned everything produced by Interval artists.[5] Both labs published art-related articles and books and patented several innovations.

The Interactive Institute was established by the Swedish government's Foundation for Strategic Research in 1998 and is organized around semi-independent "studios" throughout Sweden. Each studio has its own theme such as Play, Space, Tools, and Mobility. Their projects exhibit regularly at venues as diverse as art museums, corporations, hospitals, and prisons. The Smart Studio in Stockholm is the Institute's most explicitly arts-oriented studio. The Smart Studio's most visible project is "Brain Ball," a table with a rolling ball whose movements are controlled by the players' brain waves via electrodes. The Institute is moving Brain Ball out of the research lab into the marketplace, in part to make it a commercial product but also to keep the Smart Studio free from business issues. All work done in the Foundation's Studios are publicly accessible.[5]

NanoArt 21

NanoArt 21 was founded in 2004 to promote Science/Engineering–Art/Design collaborations and to establish NanoArt as a new artistic-scientific discipline. Since 2004, NanoArt 21 has successfully organized NanoArt International competitions, festivals, and exhibitions around the world.[7]

NanoArt has hosted international online competitions annually since 2006. Since 2006, participation in NanoArt competitions has doubled, from 22 artists from 6 countries in 2006 to 42 artists from 14 countries in 2011. The number of artworks submitted to the competition has also creased, from 71 in 2006 to 149 in 2011. International reputable jurors with science and art backgrounds include: Jeanne Brasile8, Rocky Rawstern[9], Pilar Irala[10], Guillermo Munoz[11], Anatoli Korkin[12], Hugh McGrory[13], and for the 2012 edition of the competition, Roger Malina[14] and Michal Brzezinski[15].

All submitted works can be viewed on the NanoArt 21 exhibition site.[16]

The 1st International Festival of NanoArt, sponsored by Kotkan Valokuvakeskus Gallery and NanoArt 21 was hosted in Finland between May 4 and May 26, 2007. This event curated by

artist-scientist Cris Orfescu (USA) and gallery director, artist Timo Mahonen (Finland) was the first ever to bring so many nanoartists together in a brick-and-mortar gallery. NanoArt works by 15 artists from 4 countries were exhibited.[17] Most of these artists participated to the NanoArt 2006 International Online Competition.[18]

The second edition of the Festival was sponsored by NanoArt 21 and NAHVISION Institute for International Culture Exchange.[19] The event took place in Stuttgart, Germany between November 1st and November 30th, 2008. Cris Orfescu (USA) and art professor Dorothea Fleiss (Germany) co-curated the exhibit. Artists from eight countries submitted works at this invitational event. [20]

The NanoArt exhibition at EuroNanoForum 2009 in Prague, Czech Republic, featured 14 artists from around the globe and was co-sponsored by NanoArt 21 and NANO - the Magazine for Small Science.[21]

The 2010 Passion for Knowledge Festival in San Sebastian, Spain, brought world leading scientists and humanists together from different disciplines and cultures to celebrate the 10th anniversary of the Donostia International Physics Center committed to scientific progress driven by the ongoing pursuit of knowledge. A NanoArt 21 exhibition curated by Cris Orfescu (USA) and Igor Campillo Santos (Spain) and featuring 2D, video, and multimedia works by 31 worldwide artists was one of the highlights of the festival. This event included artworks created by Top 10 artists at 4 editions of the NanoArt International Online Competition organized by NanoArt 21.[22]

After the show, the artworks were exhibited in different research centers in San Sebastian: nanoGUNE, DIPC, the Faculty of Chemistry, and other venues.[23]

A large number of international nanoartists (24) showed their works in an invited NanoArt exhibition at Nano Israel 2012, exhibition curated by Cris Orfescu and co-sponsored by NanoArt 21 and Epson. After the exhibition, the artworks were donated to different Universities to spread the knowledge about NanoArt as a new art discipline and movement reflecting the progress of the technology and science. The exhibition was acknowledged by major publications like Haaretz, which is similar to the Wall Street Journal for Israel, a newspaper read by the local elite and by decision makers. The show was hosted at David InterContinental Hotel in Tel Aviv.[24]

These are a few examples of events organized by NanoArt 21 during its first 6 years of existence. Ultimately, a NanoArt movement was created. In the future, NanoArt 21 will focus increasingly on education. The founder (Cris Orfescu) envisioned NanoArt 21 as an international organization which offers resident programs for artist-scientist teams to help understand this new discipline and create NanoArt works in science-art lab-studios equipped with electron, atomic force, and other advanced microscopes for the manipulation of matter at molecular and atomic scales and to visualize nanosculptures and nanolandscapes. Research equipment to facilitate the creation of the nanostructures and artistic tools for nanoartists to help them convert the scientific images in artworks will be also added to the facility. The art projects in a research environment will stimulate the researchers adding aesthetic and emotional value to the scientific work, will

provide grounds for developing new skills, and lead to new discoveries. A permanent gallery will showcase works created by the center's residents.

Art sales and in-house projects for developing new products will help finance the organization and offset a small amount of overhead fees.

External industrial and commercial projects will also raise funds as well as encourage relationships with local industries, academic institutions and other artist communities.

Primary funding venues would be local and federal government.

However, to accomplish this project there is still need for a strong sponsorship in spite of the programs initiated in-house. Nanotech companies would be an excellent source for funding considering the PR power that our organization would have as an artistic institution. However, we'll not promote products that are not compatible with a responsible nanotechnology development such as nanoweapons or other sources of "portable apocalypse."

Suggested Actions

Actions are directed towards but not limited to the following groups. When possible, specific actions correspond with the appropriate group or groups and appear in parentheses.

A. Board Members
B. Shareholders
C. General Public
D. External Academic institutions, groups, universities, etc
E. External Commercial businesses, corporations, etc.
F. Partner / Similar NPO's
G. Artists
H. Scientists

Suggested Action Categories:
1. Capital Campaign
2. Content
3. Curricular / Studio
4. Exhibitions
5. Materials and Supplies

1. Capital Campaign:
       a. Establish financial goals of capital campaign and possible budget (A)
       b. Establish fundraising plans (ie: who to contact and when, fundraisers to hold, etc) (A)
       c. Possible fundraising possibilities to pursue:
              i. Local and Federal Governments (A)
             ii. Similar NPO's (A)
           iii. Universities and other academic institutions. (A)

iv. Shareholders (A, B)
v. General Public (A,C)
vi. Commercial businesses, corporations, etc (A, E)
vii. Brainstorm further / alternative sources of funds (A).

2. Content:
    a. Establish bylaws of NanoArt 21 (A)
    b. Determine board members [ie: Director, President, Vice President, Treasurer, Secretary, etc.] and their respective roles. (A)
    c. Identify long and short term goals for NanoArt 21 (A, B)
    d. Determine physical needs [ie: materials, building, studio space, etc] (A)

3. Curricular / Studio:
    a. Define residential programs and studio opportunities (A)
    b. Pursue art / science collaborations (G, H)
    c. Organize on-line competitions and educational events for k12 students (A, C)

4. Exhibitions:
    a. Plan online exhibitions and invite participants (A, D, E, F, G, H)
    b. Plan brick and mortar exhibitions and invite participants (A, D, E, F, G, H)

5. Space / Equipment / Materials / Supplies:
    a. Build studio and exhibition space (A – H)
    a. Secure scientific equipment and contact universities, corporations or the general public for physical donations. (A, C, E, F)
    b. Secure traditional art supplies [ie: paint, paper, markers, pastels, etc] and contact universities, corporations or the general public for physical donations. (A, C, E, F)

References

1. Cris Orfescu, "NanoArt: Nanotechnology and Art", chapter 8 in"Biologically-Inspired Computing for the Arts: Scientific Data through Graphics", edited by Anna Ursyn, 2012, IGI Global

2. George, E. Palade EM Slide Collection, Harvey Cushing/John Hay Whitney Medical Library, http://cushing.med.yale.edu/gsdl/cgi-bin/library?p=about&c=palade
3. http://nanoart21.org/nanoart.html
4. http://nano.arts.ucla.edu/index2.php
5. Michael Naimark, "Technology-Based Art and the Dynamics of Sustainability", A report for Leonardo Journal supported by the Rockefeller Foundation.
6. Craig Harris, editor, "Art and Innovation", MIT Press
7. http://nanoart21.org
8. US artist, director and primary curator of the Walsh Gallery at Seton Hall University

9. US artist and consultant, editor emeritus of Nanotechnology Now, Foresight Senior Associate

10. Curator and art critic from Spain, PhD in History of Art

11. Physicist from Spain, PhD in Photonics

12. Associate Research Professor at Arizona State University, President of Nano & Giga Solutions, PhD in Physics from Moscow Lomonosov State University

13. Irish filmmaker and photographer, NanoArt pioneer creating moving images of the living cell, and Creative Director of Culture Shock Marketing in New York City

14. French research astronomer, Member of the Board for Leonardo organizations, Leonardo publications coordinator at MIT Press, co-chair of the art-science program at IMERA in Marseille, and distinguished professor of Physics and Art and Technology at the University of Texas, Dallas

15. Polish artist combining software and video with biological material systems, culture futurologist, curator at the Museum of Art in Lodz, the Center for Contemporary Art Laznia in Gdansk, and the Contemporary Art Center Bunkier Sztuki, in Krakow

16. http://nanoart21.org/nanoart-exhibitions/

17. Chris Marshall (Australia), Carol Cooper (Canada), Bjoern Daempfling (Germany), A. John Valois (USA), Abigail Kurtz Migala (USA), Chris Robinson (USA), Cris Orfescu (USA), Darcy Lewis (USA), Dolores Glover Kaufman (USA), Fred Marinello (USA), Gregory O'Toole (USA), Jan Kirstein (USA), K. Elise Cohen (USA), Lisa Black (USA), and Ursula Freer (USA)

18. http://www.nanotech-now.com/columns/?article=067

19. http://nanoartfestival-stuttgart.blogspot.com

20. Geert Lensens (Belgium), Hugh McGrory (Ireland), Teresa Majerus (Luxembourg), Bjoern Daempfling (Germany), Dorothea Fleiss (Germany), Han Halewijn (Netherlands), Elena Lucia Constantinescu (Romania), Teja Krasek (Slovenia), Chris Robinson (USA), Cris Orfescu (USA), David Derr (USA), David Hylton (USA), Jan Kirstein (USA), Judith Lightfeather (USA), Lisa Black (USA), Siddhartha Pathak (USA), and Steven Pollard (USA)

21. http://www.euronanoforum2009.eu/nano-for-public/index.php

22. Imamedin Amiraslan (Azerbaijan), Daniela Caceta (Brazil), Maria Matheus (Brazil), Ricardo Tranquilin (Brazil), Bjoern Daempfling (Germany), Jan Schmoranzer (Germany), Gilberto Sossella (Italy), Simone Battiston (Italy), Teresa Majerus (Luxemburg), Pilar Ruiz Azuara (Mexico), Han Halewijn (Netherlands), Elena Lucia Constantinescu (Romania), Janko Jelenc (Slovenia), Teja Krasek (Slovenia), Frances Geesin (UK), Leonel Marques (UK), Anna Ursyn (USA), Carol Flaitz (USA), Chris Robinson (USA), Cris Orfescu (USA), Darcy Lewis (USA), David Derr (USA), David Hylton (USA), Janis Kirstein (USA), Jean Constant (USA), Linda Alterwitz (USA), Lisa Black (USA), Patrick Millard (USA), Shruti Gour (USA), Deeraj Roy (USA), and Steven Pollard (USA)

23. http://dipc.ehu.es/down/memoria_completa10-11.pdf

24. http://nanoart21.org/blog/nanoart/nanoart-works-at-nanoisrael-2012-conference-and-exhibition

SARC (Scientists/Artists Research Collaborations)

http://wp.me/P2oVig-kW

Coordinator: Jack Ox and Richard Lowenberg

Disclaimer Note: The SARC Summer 2012 pilot initiative accomplished many intended objective outcomes, garnered partners and served as the impetus for program next phase development.   There is currently no pragmatic reality to SARC's ongoing programmatic life and works, though. This White Paper, therefore, lays out SARC resources, structural considerations and intentions.   At this point, SARC reality and creative potential is being dedicatedly developed, but uncertain. It is from the grounded reality of SARC development that we will form some action points.

Introduction

Most of society, and even many of us who think about these issues, do not fully recognize or understand the processes and potential of what we are calling SEAD; and in not understanding we undermine this potential.   The convergence of the arts with design, engineering, science, education and many other human endeavors and social trends, is proliferating everywhere around us. Creativity across and beyond self-limiting disciplines is a natural evolutionary tendency in all of us, nurtured today by the opportune-rich emergence of greater social freedoms, openness and democratization. This includes technological development, understood as part of our sensate tuning-in to a wondrous information ecosystem, adding to our new real-life worldviews.

Creativity in this context is being driven by a perceived need to think different; to apply new, complex yet holistic understandings to critically troubling issues facing our world and ourselves. SEAD requires honest, open-mindedness. It should not fall into the trap of old way categorizations, academic curricula and evaluative measurements, but should rather be understood as a social movement; an evolutionary response to our mysterious humane journey.

SARC is a new initiative that intends to develop and set grounded examples for an eco-social understanding of SEAD, aspiring to create and further highest level achievements and valued benefits. We intend to frame SARC initiatives by asking some of the most important, difficult questions of our time, and by telling inspiring stories, under the project code name "ECOS". SARC has lofty ambitions, because we feel that it is necessary to work at appropriate scale and effect. We are just getting started. We have no assurance of success. It will not be easy.

SARC Summer 2012

The Scientists/Artists Research Collaborations (SARC) initiative was piloted during Summer 2012 as a project of 516 ARTS, for ISEA2012 (International Symposium on Electronic Art) www.isea2012.org, just held in Albuquerque, Los Alamos and Santa Fe in late September.

SARC Pilot Co-Directors:

Jack Ox, Associate Research Professor, Music, UNM jackox@comcast.net
Richard Lowenberg, Art and Science Laboratory / SARC   richard@artscilab.com

SARC research institution partners to date are the Los Alamos and Sandia National Laboratories, with the collaboration of University of New Mexico's Center for Advanced Research Computing (CARC) and Santa Fe Institute.

SARC has been funded to date by Lockheed Martin/Sandia National Laboratories and the New Mexico Consortium, with additional supporting company sponsors: Los Alamos National Bank, CenturyLink/Qwest Communications and Qforma.

Five SARC artist collaborators were selected from over 75 applicants for the ISEA2012 Summer pilot:

- Ruth West, UCSD Center for Research in Computing and the Arts (CRCA), San Diego.
- Francesca Samsel, working w/ visualization labs at UT El Paso and UT Austin, TX.
- William Ray Wilson, (Navajo) Institute of American Indian Arts, Santa Fe, NM.
- Adrianne Wortzel, New York City College of Technology, City University of New York.
- Todd Ingalls, Grad. Studies Chair, Arts, Media, Engineering School, ASU, Tempe, AZ.

> *"I'm interested in developing new modes of inquiry that bridge art and science in order to go beyond what we can already see and know through the training and technologies we possess. Working across disciplines with researchers in the sciences, I can develop research with hybrid outcomes that contribute new knowledge as well as public-facing experiences that bring complex science to general audiences."*
>
> Ruth West, Strategist at the Center for Research in Computing and the Arts at the University of California San Diego. SARC artist and advisor.

SARC co-directors and artists initiated preliminary interactions and discussions on-site and remotely during the Summer, with a July visit and follow-on communications with science research teams at Los Alamos and Sandia National Labs, Santa Fe Institute and UNM. In this first phase, the SARC artists and science research teams brought up shared interest and experience in cross-disciplinary work with large data sets, complex eco-systems modeling and applications, food and health issues, advanced visualization and sonification techniques, cognition, memory and perception studies, and creative talents applied to critical social and environmental understandings, decision-making processes and problem solving.

SARC did not contrive to immediately pair up an individual scientist with an artist; nor did it simply expect pre-proposed projects to be the basis for collaboration. It instead intends that groups of artists and scientists begin to communicate among each other, to meet in scheduled site visits and begin to have in-depth discussions about the nature of art-science collaborations; about the potential extents and limitations of what may reasonably be accomplished through initial

interactions; and about areas of joint research which may emerge, and may be considered for ongoing collaboration and support. Rapport among individuals, funding, and researchers' allocation of time were understood to be among essential collaborative determinants.

The SARC Summer pilot program resulted in the following outcomes, deliverables and ongoing efforts, beginning with July artists and scientists meetings, interactions and presentations.

- Fri., July 6: SARC initiated its commitment to education and public outreach with a special "3D-VIS" presentation, featuring the latest active 3D visualizations produced by LANL and Sandia teams, as a special program of the Currents: Santa Fe International New Media Festival.

- July 9 and July 11: SARC artists had arranged presentations/discussions with potentially interested science researchers a Sandia Labs/CERL and at LANL. During July, artists and guests given security passes, also toured the 'restricted' Vault behind the fence at LANL, to see demonstrations of active 3D visualization facilities: the CAVE (La Cueva) and the Powerwall, with presentations of nano-structures, asteroid impacts, explosion dynamics and ribosome structures. Scheduled meetings with LANL researchers were held in conferencing/workspaces provided at the New Mexico Consortium.

  > *"Cross-disciplinary collaboration is essential to 21st century science, engineering, and biomedicine, and is deeply integrated into the fabric of supercomputing at UNM. SARC will continue CARC's tradition of collaboration at the nexus of art, science, and technology. We believe that the greatest insights and advances will result from unexpected encounters among creative researchers who are willing to take the leap and reach beyond the strict confines of their fields."*

  > Susan R. Atlas, Ph.D., Physicist, Director of the UNM Center for Advanced Research Computing (CARC), and a theoretical scientist leading research groups in nano-science and computational cancer biology.

From September 15 through 25, SARC conducted three public panels/presentations and a private, invitational Working Group meeting at Santa Fe Institute, in conjunction with ISEA2012.

- Saturday, September 15, 1:00-5:00 p.m.: ISEA2012: "Art & Science: a presentation at the Bradbury Museum in Los Alamos, a featured program of "The Next Big Idea", presented and discussed the processes used by the artists and scientists during their collaborations.

- Monday and Tuesday, Sept. 17 and 18: Santa Fe Institute, SARC Working Group, with 20 invited (national) participants, discussed the future of SARC and Art/Science in general, with a focus on pragmatic next-phase strategies. A major focus and action-agenda item was curriculum for art/sci (STEAM) education, as well as funding options. We were fortunate to be able to coordinate agendas with NEA and SEAD representatives. In addition to SARC directors and artists, participants included: Laura Monroe, LANL; David Rogers, Sandia

Labs; Bill O'Brian, NEA; Deana Pennington, UT El Paso; Carol LaFayette, TAMU and Roger Malina, UT Dallas; Andrea Polli, UNM; Thomas Caudell, UNM; Jim Crutchfield, UC Davis; David Dunn; and Jennifer Dunne, SFI.

- Thursday, September 20, 9:00-10:20 a.m.: ISEA2012: "SARC: Art & Science": artists and science researchers' presentations at the Natural History Museum in Albuquerque. |
- An exhibition of ISEA2012 Residency works (w/ SARC) opened at UNM School of Architecture, on Sept. 19th. SARC information is on the ISEA2012 web site and in the ISEA2012 catalogue and all publications.

- Tuesday, September 25, 1:30-3:30 p.m.: ISEA2012: "Art & Science: The SARC Process" presentation at Santa Fe University of Art and Design, with participation of 25+ students from New Mexico School for the Arts, and a class from Santa Fe Community College, plus many US and international ISEA2012 participants attending Santa Fe Day events.

> *"A portion of my research is focused on developing and testing immersive virtual reality interfaces to complex datasets and simulations. The use of virtual reality (VR) technology provides an opportunity, for the first time in the history of computation, to immerse scientists, with all of their naturally evolved human perception and reasoning, directly into multidimensional multiodal representations of their software and data. I believe that many new representations will blossom through the collaboration between art and science, allowing us to reach many new levels of comprehension."*
>
> Thomas Preston Caudell, Ph.D., Prof., Dept. of Electrical & Computer Engineering, Dept. of Computer Science and Dept. of Psychology, UNM (coined the term" 'Augmented Reality')

- Leonardo, an M.I.T. Press publication, will feature an editorial on SARC, and the NSF funded SEAD (Science, Engineering, Art, Design) initiative will publish a 'white paper' on the SARC program, including intended next phase efforts.

- The New Mexico Consortium prepared a SARC press release, and an article for Essence, Los Alamos' monthly events paper, in coordination with the 2012 Next Big Idea Festival.

- Development of SARC higher education programs is currently in early stage discussions with UNM, SFUAD, IAIA, UT Dallas, UC Davis, other university contacts and funders.

- A newly forming Advisory Group, currently includes Andrea Polli, Associate Professor of Art and Ecology, at UNM; and Roger Malina, Professor, UT Dallas, and Executive Editor of Leonardo Publications at M.I.T Press.

- There are currently two SARC web blog sites, one http://nmsarc.wordpress.com for public information, and one for use by collaborating artists and scientists. SARC's developing online presence will also serve to coordinate and communicate among the newly established SARC Pool, an ever-extended pool of creative collaborators.

North Central New Mexico: Place-Based Assets, Needs and Opportunities

North Central New Mexico is home to a number of the nation's leading science and technology research institutions and to a globally acclaimed arts community, within a rich multi-cultural and bioregional "land of enchantment" setting. The region encompasses Taos, Espanola, Santa Fe, Los Alamos, Rio Rancho and Albuquerque, plus many more rural and pueblo communities.

Santa Fe has a vital and diverse arts and cultural economy, designated as an official UNESCO Creative City. Santa Fe Institute and the Center for Non-Linear Studies at Los Alamos Laboratory, have made this the dynamic center of the 'complexity sciences' community. Santa Fe is home to the National Center for Genomic Resources, as well as the Institute of American Indian Arts, Santa Fe University of Art and Design and St. Johns University.

Los Alamos is currently taking big steps forward on "Next Big Ideas", to leverage its science and technology research economy with a new cultural plan and initiatives to economically vitalize that community, including a potential community-wide fiber-to-the-premises initiative.

Sandia National Laboratories is in Albuquerque, and Intel has major facilities in nearby Rio Rancho. University of New Mexico, with main campus in Albuquerque, is the state's leading research university, with satellite campuses In Los Alamos and Taos.
Beyond this north central region, the State of New Mexico has other rich arts, sciences and technology resources, including the other two state research universities (NMSU in Las Cruces and NM Tech. in Socorro), the Navajo Nation, the Large Array, and the NM Spaceport.

North Central New Mexico also lives with a responsibility to transform a number of 'wicked' undermining eco-social problems. K-12 education attainment in New Mexico is near the bottom of all state rankings; with the same true for broadband adoption. As is the case everywhere, this region must better address long-term economy, healthcare, energy and water resource issues. And, while our National Labs are major science centers, their nuclear weapons work presents and represents among the greatest controversies and risks for the survival of life on this planet.

SARC is intended as a means to grow a more vibrant future for this region with its unique resources, needs and opportunities. SARC intends to work in coordination with other regional public and private sector planning, incubating and realizing efforts, so as to foster most broadly benefiting impacts, investment strategies, creative visions and social outcomes.
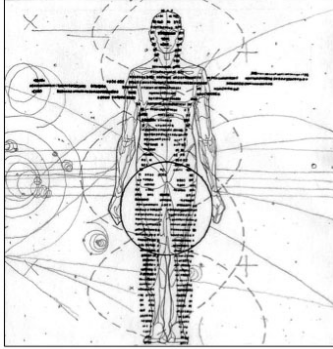
SARC Next Phase: 2012-2014

While there are complexities and difficulties yet to be understood and addressed, a number of encouraging opportunities have emerged in this first round of efforts to institute an arts/sciences initiative in New Mexico. We therefore intend to now build upon this Summer's collaborative start-up, on lessons learned and on determined best-practices, to become an ongoing initiative emerging to have convergent benefits:

- For the sciences
- For the arts
- For education
- For society

For its ongoing life, SARC is now a program of the Santa Fe based Art and Science Laboratory (ArtSciLab), a 501(c)(3) nonprofit organization. ArtSciLab, founded in 2000 by composer David Dunn and 'complexity' physicist Jim Crutchfield, with Woody and Steina Vasulka and others, having set example for among the best in art/sci collaborations over many years, is an ideal fiscal organization home for SARC, and other possible cross-sector programs. http://artscilab.com

> *"Artists have a different skill set and training than scientists, and in particular, use their abilities to present complex ideas in a way that can be understood. We all live in a visually sophisticated society, and are familiar with visual language and metaphor, but these have not fully made their way into the scientific enterprise. Our culture is aesthetically sophisticated. Scientists share in this common culture, and we think that this collaboration of artists with LANL scientists should lead to innovative presentation of scientific research of national significance, and may lead the scientists to regard their work in ways not before considered."*
>
> Laura Monroe, Ph.D., Mathematician, LANL Production Visualization Project Leader in DoE's Advanced Simulation and Computer program, and Team Leader of the Special Projects Team in LANL's High Performance Computing division.

As we now proceed to build upon this Summer's initiating efforts, to shape an organizational, programs and budgetary agenda for the next two years, a number of intentions are emerging.

ArtSciLab/SARC aspires:

- To go beyond 'techne' to address more fundamental, all-encompassing ideas and issues.
- To focus on critical issues facing society, the sciences and the arts, in creation of projects.
- To partner to create 'great works' in the context of great challenges and opportunities.
- To demonstrate by example, collaborative processes, economic structuring and benefits.
- To provoke serious research, experimentation, play, trial and error, and elegant solutions.
- To take shared team approaches to research, learning, production and communication.
- To work with the SEAD community to add strength to our mutual advocacy and actions.
- To incorporate the cultural richness and indigenous knowledge in this geographic region.
- To advocate and set example for convergent arts/sciences for community eco-vitalization.

These underpinnings and intentions are helping us to shape a set of primary and peripheral programs, limited or made real by budgets, that separately and in total demonstrate a complex, dynamic and emergent 'ecosystems' approach to our convergent, hybrid practice: "ECOS".

ArtSciLab/SARC next-phase programs through 2014 are proposed:

- To strengthen existing arts, sciences, education and community institutional relationships.
- To develop an innovative economic support strategy for ArtSciLab's SARC initiatives.
- To host a series of (monthly) public seminars and workshops with artists and scientists.
- To establish and produce a 'new works' in the arts and sciences commissioning program.
- To organize an annual New Mexico (Los Alamos/Santa Fe) "Arts & Sciences Festival".
- To participate in networked arts/sciences interactions nationally and globally.

ArtSciLab/SARC is proposing an ambitious agenda for this New Mexico based co-laboratory. We look forward to extending our efforts to include other SEAD practitioners and programs, and to thereby add to our knowledge-based 'common pool assets.'

Obstacles, Opportunities and Suggested Actions

There are numerous obstacles, but also many yet untapped opportunities inherent to SEAD efforts. Some are general to almost all involvements, while some are specific to the many variations of SEAD collaborations, whether led by universities, corporations, government agencies, foundations, research institutions or individuals. For instance, adequate and appropriate funding or financing is a general problem, while issues such as security restrictions are specific to SARC and its collaborations with the National Laboratories (LANL/Sandia).

Addressing the issues, obstacles, difficulties, opportunities and suggested actions requires detailed assessment, specific to each potential players and sector (SEAD / SARC / artists and designers / scientists and engineers / research institutions / companies / educational institutions / funders and underwriters / communities and society / and other partners and participants). ArtSciLab/SARC's efforts are informed by years of lessons learned, best-practice experiences, humane insights and creative responses to the obstacles and opportunities of the moment.

Ultimately, it is experience and intent to achieve highest quality, intelligent, creative and mutually benefiting outcomes of the process and the work that will make a necessary difference.

SARC intentions, experience and fundamental understandings include requirements for:

- Personal rapport and mutual respect among potential collaborators.
- Creative open-mindedness, with complementary skills and understandings.
- Valuation of processes and outcomes with benefits for SEAD partners and for society.
- Ability to undertake necessary long-term, collaborative, cross-disciplinary R&D.
- Innovative funding and investment strategies with: .gov, .mil, .com, .edu, .org and .art.
- Artful example-setting in all aspects of SEAD programs.

Following is a one page "Call to Arts", advocating for greater eco-social responsibility in the arts, necessary for any meaningful work to result from SEAD initiatives.   Similar one page 'calls' will be prepared for the sciences, for education and for society.

A Call to Arts

In this age, increasingly shaped by communications and technology, humanity is becoming acutely sensitive to its frail security. The rationalism of science continues to accelerate the conflict between global mind and local body. Energy and information are now our major exchangeable natural resources. They constitute the primary foundation of the value system in a newly emerging economic structure.

Within the broad framework of information theory, the arts are recognized for their communicative effectiveness and transcendence. The processes of creativity, though elusive, have lead mankind through historical mazes of uncertainty. In an information-based society, cultural development may assume an economic value comparable to commercial development in industrialized society. Having learned to recognize the complex ecological interdependence of living systems and the environment, artists now have opportunities to produce models for a sustaining cultural ecology.

The arts, reflecting the state of today's larger political, economic and social systems, are in serious trouble. Too many artists are playing it safe. The role of the arts in our society is increasingly shaped by confused intellectualism; selfish vested-interest capitalism; and absent-minded, fashionably crafted artificiality. At the same time, the rich diversity of wilderness and indigenous cultures around the world, are increasingly being valued for their scarcity and novelty, while being exterminated and replaced by the greed of progress and 'new world orders'.

There is a critical need and an all important opportunity for creative people, artists, to take advantage of the great independence and freedom inherent in their calling, to take a more active personal responsibility to be proponents of a true sense of ecology; a cultural ecology.

To call oneself 'artist', is either a grand conceit, or a bold decision to assume greater individual creative freedom. That freedom ought to carry with it, a responsibility for honesty and transformative intelligence. Artists, having chosen a freedom of aesthetic and intellectual vision

and pursuit, are often at odds or in conflict with prevailing social norms. This is precisely the artist's value. The artist is in a way, the personification of society's means of checks and balances; a sensate explorer seeking to be 'in tune'.

If we take the incentive of applying our creative talents towards an ecologically considered future, we must be comprehensive. Society is in need of clear, intelligent, inspired under-standings and visions, the nonmaterial assets that constitute the true wealth and aspirations of a culturally secure community. As technological development shapes our concepts of the future, artists working with new tools and processes need to weigh the eco-cultural worth of their endeavors, to not merely be narrow-minded advocates of technological consumerism. As communications systems advance into the 'photonic era', where will we find enlightenment?

Will artists, synaesthetic pathfinders, contemporary tricksters, lead the charge for a real Information Revolution?   Artists, as cultural agents, must make some difficult decisions, but have equally exciting opportunities to set examples, create models, and express simple truths. Amid life's complex compromises, creative idealism must be part of the equation.

--- R. Lowenberg

The Coming of Age of a PhD Program in Digital and Experimental Arts Practice: Lessons Learned and Challenges for the Future

http://wp.me/P2oVig-nu

Coordinators: Juan Pampin, James Coupe, Center for Digital Arts and Experimental Media (DXARTS), University of Washington

Introduction

The Center for Digital Art and Experimental Media (DXARTS) is based at the University of Washington in Seattle, USA. Over the last five years, it has established itself as one of the leading research centers for digital art in the USA. No commercially-sponsored research is undertaken, and DXARTS' highly selective PhD program offers full tuition waivers and stipends to its students. Students are expected to develop original research specializations based on their art practices, and receive support and resources to establish long-term legacies for the program. Unusually for a digital arts program, DXARTS has invested heavily in non-screen based studio facilities, including a 5000 square foot warehouse that incorporates state of the art CNC fabrication, electronics laboratories, exhibition space, as well as more traditional wood and metal workshops. DXARTS actively pursues interdisciplinary collaborations across the University, including affiliations with Music, Art, Dance, Computer Science, Engineering, Physics and Biology. Visiting scholars include scientists as well as artists, and the program includes post-doctoral researchers with PhDs in Computer Science and Engineering and other STEM fields.

As such, DXARTS is positioning itself to fully explore the notion of artistic experimentation in the 21st Century. This experimentation is a cross-disciplinary endeavor that requires a new generation of artists, with expertise in computing and the sciences who have followed a research and teaching agenda equivalent to those found in other fields (rather than the traditionally terminal degree in the visual arts, the MFA). New and unusual research strands have emerged as a result, resulting in publications and patents that make broad contributions across multiple disciplines.

DXARTS can therefore be considered as a new kind of research center, asserting the value of artistic knowledge and problem-solving and claiming it as equivalent to that in other fields, and of vital importance. Nevertheless, funding models for DXARTS are to be found in the arts rather than in the sciences, resulting in a lack of substantial, long-term resources to pursue its research trajectories. In the arts, with a lack of national arts funding organizations, this means commissions, competitions, and local art grants. Access to NSF-style funding is problematic due to a lack of recognition of the value of creative research, and a lack of access to program managers in funding agencies. Whereas a scientist would develop necessary funding relationships via their PhD and postdoctoral advisors, a PhD student in creative technology fields has no conventional route to acquire funding appropriate to their research.

Brief history of DXARTS and its PhD program

• 1993: with the approval of the Dean of the College of Arts and Sciences, Music Professor Richard Karpen is named director of the The Humanities and Arts Computer Center (HACC). Karpen changes the name of the center to Center for Advanced Research Technology in the Arts and Humanities (CARTAH) subsequently obtaining substantial founding to radically change the mission of the center, which supported advanced project-based digital research across the arts and humanities including, video, audio, text and design.

• 1999: Karpen and faculty from three different departments applied to a university funded grant called Tools for Transformation. Their proposal "Advanced Arts Technology Initiative" received $550,000 in funding for two years. With this grant, CARTAH expanded its research scope, funding graduate students from the arts that worked as research assistants at the center and creating two postgraduate positions.

• 2001: Professor Karpen and a team of faculty from three colleges applied to another internal grant called University Initiatives Fund (UIF). This grant was created by taxing academic units 1% of their budgets to create a large pool of money for new academic initiatives. Professor Karpen and his team were awarded $700,000 of annual permanent funding to create DXARTS.

• 2002-2003: DXARTS PhD program proposal is submitted and approved by the UW Board of Regents and the State of Washington's Higher Education Coordinating Board.

• 2004: DXARTS moves into its new on-campus facilities in Raitt Hall. First group of PhD students start the program.

• 2005: Fremont Fab Lab off-campus facilities are created, including a 5000 square foot warehouse incorporating state of the art CNC fabrication tools, electronics laboratories, exhibition space, as well as more traditional wood and metal workshops.

• 2008: DXARTS goes through its first program review. The review committee included UW faculty form Biology, Law and Mathematics as well as two external experts.

• 2009: James Coupe is first PhD student to graduate from the program.

Lessons Learned

Since 2009, six PhD students graduated from our program, five of them are women, something unusual for a technology-centered program like DXARTS. Most of our alumni are currently teaching at media arts programs or working in the industry, all of them continuing their international artistic careers. In the last few years our PhD program has developed an international reputation, attracting students from around the world; we continue to have a permanent cohort of about fifteen PhD students that are fully-funded and work at DXARTS as teaching and research assistants.

While this could sound as a wonderful success story, there were a number of lessons we have learned through the process of creating and sustaining our PhD program. In particular the economic crisis unveiled many structural problems related to the way the center was run and funded and to its place in academic structure of the university. Below we list the most important ones in the context of SEAD.

• Our center doesn't have its own faculty lines. It was originally created with four faculty lines from joint departments: two from the School of Music and two from the School of Art, a fifth line from the Dance Department was added in 2007. In 2009, in the midst of the economy crisis, the center lost one of its faculty from the School of Art, and that position was recaptured by the college. With only four faculty –two of them with important administrative appointments– and with some important austerity measures imposed on the UW by the State (including serious budget cuts and a hire freeze), the center couldn't continue to grow at the rate expected and encouraged by the 2008 program review, which recommended DXARTS should be granted full departmental status with full control of its faculty lines and be given two extra lines on top of the five it had at the moment of the review. Having a reduced number of faculty and limited resources had two immediate consequences: first, our faculty couldn't continue to do research at the level of intensity of the previous years; second, our PhD students had to share the teaching and supervision of our undergraduate students with the faculty, further reducing their research time.

• State budget cuts affected the state funding for education at all levels, in particular the funding for the arts was dramatically cut at the elementary, middle and high schools. This had a direct impact on the level of the students applying to our BFA program –mostly in-state students– and forced DXARTS to implement remedial classes to teach arts foundations and history to the incoming students, demanding more time and supervision from our graduate students and faculty. With the crisis, job security became a central concern of parents sending their kids to college, resulting in a strong interest in professional degrees, many parents and students wrongly considering DXARTS a gateway into the animation industry rather than a media arts studio program. This had a direct effect in the number of admissions to our BFA program, going down from two digits to one from 2008 to 2011. However, the reduction in the number of students incoming to our BFA program didn't alleviate the teaching demands, still requiring many hours from our faculty and graduate students.

• With State budget cuts reducing the UW funding by more by half in a few years and without external sources of funding available, the center was at the mercy of the austerity measures implemented by the university, that in 2009 asked departments to do budgets projections with up to 12% cuts. While budget cuts of these dimensions have never been put in place by the college, faculty lines were frozen as well as faculty and staff salaries (this also had an impact on our center, losing highly qualified staff that decided to leave their positions for better paid jobs). It is crucial for a young research center as DXARTS to find alternative sources of funding in order to keep its thrust and to avoid having its continuity challenged by State budget cuts that can continue in the next few years. The main mandate of DXARTS is to do artistic research, not commercially-sponsored research, this limits the possible sources of external funding to commissions, competitions, and local art grants. Our faculty has been successful at getting this kind of money, but unfortunately these grants aren't substantial enough to support our graduate

students and the large art grants (like Creative Capital grants) are usually once in a life time opportunities. Alternative funding sources that could support both faculty and graduate students could be found in national agencies like NSF, but having access to this kind of funding is problematic due to a lack of recognition of the value of creative research, and a lack of access to program managers in funding agencies.

New Directions

The main mission statement of DXARTS' PhD program is:

To give digital artists the opportunity and equitable institutional support to attain the equivalent level of intellectual and professional achievement at the culmination of their graduate studies as their peers and partners in all areas of the Humanities, the Sciences, Engineering, and in the allied generative arts field of Music Composition and Computer Music, for which doctoral degrees are the normative terminal degree for graduate students.

It is clear that this statement has been challenged by some of the points presented in the previous section. Both the level of support and the opportunities to do research have been limited for our graduate students during the economic crisis, and without State support it is hard to see the university having the funds to revert this situation. Rather than considering our PhD program doomed we saw this as an opportunity for making it better and even stronger. For achieving this, some bold measures had to be taken, some of them might seem controversial but were indispensable to get our program back to its original track and for it to have a sustainable future. Below is a list of the most important ones in the context of SEAD.

• *BFA program termination:* as discussed in the previous section, our BFA program requires a level human resources that our department can't keep up with without a serious impact on faculty and graduate student research. We also believe arts foundations and history classes should be taught by the traditional art units, which have highly qualified faculty to teach them. In the last two years we have put in place a moratorium of admissions to our BFA program in order to test what the effects of terminating the program would be. We discovered that –as we suspected– the positive effects of dropping our BFA program were multiple:

• *More research and artistic output:* freeing up faculty and graduate students time demanded for teaching and supervision resulted in increased research and production. In the last couple of years DXARTS faculty have received numerous important commissions and grants and has recently produced and patented new technology that and is currently being considered for commercialization. Our PhD students also increased their artistic and research output presenting more pieces at international festivals and conferences and publishing more papers in peer-reviewed journals.

• *Open curriculum:* over the years we have seen an increase in the number of students from other art units taking our courses. This seems to indicate that our curriculum is now embedded in the arts, something that we consider a success and that we will continue to foster, trying to cross-list more of our courses with the other art units. With no need to reserve seats for our own undergraduate students, most of the seats in our classes will be open for students not just from

the arts but from all around campus. This should connect DXARTS even more with the other art units and also promote more connections with units in other colleges like CSE and EE, whose students tend to gravitate toward our classes. Along these lines goes the development of an online version of our popular survey class "Digital Art and New Media: History, Theory, and Practice" (DXARTS 200), which will be offered every quarter to a wide variety of students from around campus (between 100 to 150 students enroll to this class, for most of them this is their first exposure to media arts).

• *Curriculum flexibility:* without the rigid class requirements demanded by the BFA, the faculty could teach a more varied curriculum and create new 500-level classes which are in high demand by our graduate students and advanced undergraduates from other units.

• *Academic clarity:* dropping our BFA program makes it clear that the academic goal of DXARTS is advanced media arts research and teaching and that we are not a professional program.

• *Less administration:* without our own undergraduate students there is no need for a full-time adviser. Parts of the funds from this position can be used to offset the increasing costs of running our Fremont Fab Labs including funding an new instructional lab technician.

• *More staff time:* without the need to put a large BFA show every year, technical staff can be dedicated full time to give support to research and production.

After a two-year moratorium of admissions, the majority of the faculty has recently voted the termination of our BFA program which will be effective in the 2014-2015 academic year after all our majors graduate from the program.

• *New MFA program:* without an undergraduate program in place DXARTS can refocus on its graduate program. Over the years, it has become clear that not having a masters degree in place could be a hindrance for recruitment for our PhD program. Every year we reject applications from many students who aren't ready for our PhD program but could be just fine for an MFA program. These artists, who could be good candidates for our PhD program after completing an MFA, end up in other institutions where that academic path is in place. Having a masters program that could function as a gateway into our PhD would fix this gap and would further help consolidate our new mandate of research with a focus on graduate studies. Also having a masters program could allow international students with funding from their national governments to come to study at our center over a shorter period of time than the one required for a PhD (these grants are usually for one or two years).

After a long debate, the majority of the faculty has recently voted the creation of a new MFA program that should be in place in about two years after it is approved by the university.

• *CARTAH closure:* the Center for Advanced Research Technology in the Arts and Humanities (CARTAH) – the center where DXARTS was engendered – continued functioning as a service unit inside our department for many years. With many other digital humanities initiatives funded on campus CARTAH lost most of its clients becoming obsolete. The recaptured funds from this

center –which included a full-time staff person and a small operational budget– were used to yearly fund two graduate students and two postdoctoral positions, and the physical space of the center was used to expand our on-campus research facilities.

• *Technical staff consolidation:* staff positions in DXARTS responded to an old IT model based on a centralized server which required a full-time senior computer specialist. This position has been consolidated into a research scientist/engineer position giving support to our on-campus research facilities.

• *Administrative staff consolidation:* our BFA program demanded a full-time adviser, without our own undergraduates, our main administrator can take care of graduate advising and the funds recaptured from the adviser position used to offset the increasing costs of renting and running our Fremont Fab Lab, including funding a new instructional lab technician.

• *New research positions:* we have recently hired a postdoctoral student in computer science who is doing research in computer vision and later this year we will have a search for another postdoc for our sound area. Our plan is to keep expanding our postdoc and research scientists pool in the next few years.

• *New Visiting Faculty position:* we have recently hired Edward Shanken, art historian whose work focuses on the entwinement of art, science and technology, with a focus on experimental new media art and visual culture. Dr. Shanken will join the faculty of DXARTS in the Fall of 2013.

• *New Visiting Artist position:* we have created a two-year Visiting Artist position, in the 2013-2014 biennium this position will be occupied by media artist Yolande Harris.

Roadblocks and Suggested Actions

While DXARTS PhD has proved to be a successful model for SEAD research at the national and international level and a catalyst for change within the University of Washington, steering the program in the new direction we want presents some mayor challenges in terms of academic flexibility, founding and sustainability. The list below presents the most important roadblocks we have identified, some solutions are suggested for them, including strategies we have recently implemented at DXARTS and which are currently under evaluation.

1) *Roadblock:* **no access to funding for DXARTS faculty, PhD students and post docs to work in science and engineering labs.**

Opportunity: there has been a lot of abstract talk about how important it is for STEM researchers to interact with artists (the famous "A" missing in STEM), but for the most part there is a huge misconception of what the role of the artist should be in this exchange. In our experience most of the times science and engineering PIs consider artists as content providers or illustrators of their research rather than peer researchers with a different research methodology which could provide a radically different vantage point to their own work. Therefore its very hard for our faculty to become grant co-PIs for NSF grants or for our graduate students and postdocs to have access to

science and engineering labs. Fixing this funding gap could be a major turning point and have a strong impact for interdisciplinary research.

Proposed Action: National funding organizations such as NSF should consider creating special incentives for PIs to include artists as co-PIs in their grant proposals. Perhaps a new "Artist in the Lab" funding program should be created to address this issue. Universities should also consider having internal funding sources for interdisciplinary projects that could allow DXARTS graduate students and postdocs to have access to science and engineering labs. DXARTS has already created an important network of connections with science and engineering labs at the UW to secure access for its PhD students, but for the most part access is restricted and depends on the goodwill of the lab directors or PIs. Having university policy in place that would encourage this kind of access or even fund it, could help make these connections official and access to labs more universal for the students.

Stakeholders: NSF and other national agencies founding science and engineering research, university deans and provost.

2) *Roadblock*: no access to funding for science and engineering faculty, PhD students and postdocs to work in DXARTS.

Opportunity: this presents the flip side of roadblock #1. We consider science and engineering research an essential part of what our center does and while our faculty and graduate students are "polymaths", their artistic research methodology differs from the scientific method needed to foster new discoveries in technical areas which are crucial to advance the field of media arts. While DXARTS has enough funding to support its own faculty and graduate students our current budget wouldn't allow us to pay release time for science and engineering faculty, or graduate students and postdocs salaries. Having access to funding for hybrid positions could be a major turning point for DXARTS and have a strong impact on interdisciplinary research at the university.

Proposed Action: National funding organizations such as NSF should consider creating special funding programs for scientists and engineers to work in art research centers as DXARTS. A "Science in the Studio" funding program could address this issue providing funding for release time for faculty to join art research centers at least part time and for graduate students and postdocs to have their research hosted in these centers. To mitigate this issue, DXARTS has recently created a postdoc position for a computer scientist to work on machine vision in collaboration with our faculty and staff. While this model could certainly lead to some interesting results, it presents multiple challenges including mentoring and supervision for our computer science postdoc, as well as an uncertain career path for him, as usually postdocs in science and engineering are expected to host their publications and grants in research labs within their disciplines rather than in art units as DXARTS. One possible way to mitigate this problem would be to have our postdocs be co-hosted by DXARTS and a lab at the CSE department, allowing him to have access to CSE faculty supervision and potentially catalyzing collaborative projects between our labs. Realistically, it is hard to imagine creating this kind of hybrid positions with the current university structure which is highly compartmentalized, in particular between colleges (Arts & Sciences, Engineering, etc.).

Stakeholders: NSF and other national agencies founding science and engineering research, university deans, provost and president.

3) *Roadblock*: tenure track lines at most research universities are created within departments and not across departments and even less across colleges and this represents a major barrier for interdisciplinarity.

Opportunity: it is clear that universities would benefit from more interdisciplinary research, in fact in the last decade many universities have formed committees to address this issue but no major policy has been implemented in order to foster interdisciplinarity except for some small projects at the college level. Creating tenure track lines across units and colleges can not only address this problem but also be a more sustainable hiring model that could reduce duplicate lines in different areas of the university.

Proposed Action: the university should consider tearing down their current silo structures and promote the creation of interdisciplinary tenure track positions in arts, science and engineering. DXARTS could be a great testbed for this kind of new lines as it is already a successful model of interdisciplinarity within the arts (all tenure track positions in DXARTS are joint appointments with other art units). New guidelines would need to be created for merit evaluation and promotion for these new positions, DXARTS could again be a good model for future policy as our tenure cases are already evaluated by an interdisciplinary committee within the arts.

Stakeholders: university deans, provost and president.

4) *Roadblock*: funding organizations like NSF are highly compartmentalized into small narrow programs making it quite hard or even impossible to submit applications for interdisciplinary projects.

Opportunity: this roadblock it somewhat similar to the previous one (#3) except that it targets national funding organizations instead of the university. Organizations like NSF have distinct divisions, each of them with its own fairly narrowly targeted funding programs representing the division's goals. The panel review structure within NSF divisions discourages widely interdisciplinary proposals, as the panels that are formed to review the proposals only look at proposals within the narrow discipline of the division. As a result of this narrow structure, researchers don't even bother writing interdisciplinary proposals for NSF until there is agency acknowledgment of the value of interdisciplinary research, and well-established ways of submitting and evaluating interdisciplinary proposals. DXARTS tenure review process might serve as an abstract model for evaluation of broadly interdisciplinary proposals at an agency like NSF. Creating ad-hoc panels for evaluation of interdisciplinary proposals could not only help fund SEAD projects but also change the silo culture of the organization that seriously affects interdisciplinarity in all fields of research.

Proposed Action: national funding organizations like NSF should create special programs for interdisciplinary research with ad-hoc evaluation panels from across divisions of the agency and with external experts with experience in interdisciplinarity. It should be noted that other

countries already have this kind of model in place, for instance the FQRSC from Quebec, Canada, puts together panels with international experts from different disciplines to evaluate interdisciplinary applications to their founding programs in arts, science and technology.

Stakeholders: NSF and other national funding organizations.

4) *Roadblock:* internal funding at the university level for research in the arts is very limited and insufficient.

Opportunity: the Royalty Research Fund grants (RRF) are currently the only source of internal research funds for faculty at the UW. While this program can be quite helpful for junior faculty to develop their first large research projects, access to these grants is very limited (all the arts compete for a small number of grants) and is usually reduced to a once in a lifetime opportunity. Creating new funding opportunities with emphasis in interdisciplinary projects could be a great catalyzer for new ways of doing collaborative research and help tearing down current silo structures at the university.

Proposed Action: the university should create more internal funding mechanisms for interdisciplinary projects. These funds could come from a shared pool of money created between the different colleges or academic units. Again, DXARTS could be a great success story for this kind of model in the arts, as it was created by a University Initiatives Fund grant (UIF). This grant –which only existed for a few years– was created by taxing academic units 1% of their budgets to create a large pool of money for new initiatives. DXARTS, the Center for Nanotechnology and a few other young research centers were created with UIF funds.

Stakeholders: university chairs, deans and provost.

5) *Roadblock*: The notion of risk is treated differently between the arts and the sciences.

Opportunity: In the sciences, it is assumed that innovative research will involve a degree of risk-taking. Here, risk-taking is taken to mean work that consciously challenges existing paradigms within a field. Constructing such work may require institutional support to navigate the various legal, practical and educational implications of the research, as well as coping with the public perception of such work. Examples from the sciences may include Stem Cell Research, Human Genomics, Animal Testing, etc. In the arts, there is not the same expectation of risk-taking, or at least it cannot be considered to be on the same level as in the sciences. Many institutions, museums and galleries may describe themselves as risk-taking, yet are unable to provide the legal, practical and funding support to facilitate work that can be considered as genuinely paradigm-shifting. The result is that art research moves much slower than scientific research, and that it is very difficult for artists to maintain pace with scientific developments and innovations.

Proposed Action: The university should apply equivalent standards and resources to risk-taking in the arts and the sciences by establishing a set of criteria that can apply to both. This may require a significant shift in the expectations for arts faculty research output, which is to be encouraged.

Stakeholders: university deans, provost and president.

6) *Roadbloc*k: permanent space is not available for new SEAD units.

Opportunity: when DXARTS was created a very limited amount of on-campus space was assigned to it. It was soon clear that for the program to succeed we needed a large space where we could host our research and fabrication labs so we decided to rent a warehouse off campus. This unit –called the Fremont Fab Lab– became the core of our PhD program and we couldn't function without it, but the cost of renting and keeping the the place running represents a huge toll on our operations budget (a cost that other academic units don't have to pay as they have their own buildings). The university could benefit from having a facility like our Fab Lab on campus, as many more students from other art units would have access to them and the reduced yearly expenses could go to fund research projects rather than paying rent.

Proposed Action: the university should consider moving facilities like the Fremont Fab Lab to permanent spaces on campus. Capital campaigns for the development of new buildings on campus should include square footage for spaces like this.

Stakeholders: university deans, provost and president.

The Openlab Network Facilitates Innovative, Creative and Collaborative Research with Art, Community, Design, Technology, and Science at the University of California, Santa Cruz

http://wp.me/P2oVig-iS

Coordinator: Jennifer Parker, Associate Professor and Chair of the Art Department, co-founder and Executive Director of the OpenLab Network, as well as Affiliate Faculty of Digital Arts & New Media, UCSC; Sudhu Tewari, Ph.D. student in Cultural Musicology and Mechatronics Researcher in the Digital Arts & New Media program, UCSC; James Guillochon, Ph.D. student in Astronomy, UCSC, Laura Cassidy Rogers, Ph.D. student in Modern Thought and Literature, Stanford University.

INTRODUCTION

Obstacle1: When Jennifer Parker, an art professor at the University of California, Santa Cruz, was trying to help Enrico Ramirez-Ruiz, an astrophysics professor, assist a student on an interdisciplinary project, she was reminded (again) that neither professor had permission to share the other department's studios, labs, or facilities.

Obstacle 2: Amy Boewer, a visual art and art history undergraduate, and Jack O'Neill, a business undergraduate, each with interests in sustainability, had an idea for a convertible sleeping pad for artists, scientists in the field, low-income residents of developing countries, and even for survivors of natural disasters. But neither had a place to make their prototype or equipment to test their design.

The solution to these obstacles was the creation of the OpenLab Network, which Parker and Ramirez-Ruiz co-founded in 2010. OpenLab supports project-based initiatives combining art and science research. To inaugurate the project, Parker turned her own research lab, in the Digital Arts Research Center, into the interim OpenLab facility for project groups to meet, ideate and prototype. She advocated for participants to be given access to Art Division resources, including the metal shop, woodshop, prototyping lab, print media facilities and digital media equipment and resources. To comply with campus health and safety regulations OpenLab members were given formal training in each facility by department staff.

OPENLAB PROJECTS AT UCSC

In 2011, OpenLab held its first Summer Institute, with the theme of Art + Astrophysics. This focus allowed both Parker and Ramirez-Ruiz to support projects with their own faculty research grants, pooling resources from departments. They created four teams, each a blend of faculty, graduate students, and undergraduates across disciplines. Team members shared space, expertise, creative ideas, and differing modes of discovery on projects with multiple outcomes, researching a variety of concepts related to art + astrophysics. Parker describes the project groups as working similarly to a film crew with each team member bringing their own particular interest and expertise to a task that produced a joint outcome. Earth and Planetary Scientists and Astrophysicists proposed the concepts, then worked with artists from a variety backgrounds including sound art, digital art and new media, video, design, photography, and sculpture, in four- to seven-member teams.

OpenLab debuted their first projects in the Digital Arts Research Center at UCSC and then at an exposition at the Tech Museum of San Jose, CA, where visitors could learn about hard-to-understand concepts through these science/art projects – for instance, playing a game where they step off Earth and hurl a star into the cosmos to learn about black holes. Sudhu Tewari, a graduate student in music and art, was part of a team that developed a three-dimensional zoetrope to make visual the collision between the moon and a sister moon that orbited Earth. Working with the interplay across disciplines, artists were challenged to take real-world problems and develop solutions that would engage viewers and participants, while science faculty and students learned how to ask and answer questions that had never occurred to them where the problem existed only on paper or in the lab. Graduate students in the arts were given a very modest stipend and science graduate student researchers already working with the science faculty were given permission to work part-time or full-time over the summer on OpenLab projects. Faculty gave funds from faculty grants, office space, lab space, and equipment access, as well as unpaid time, to the OpenLab to develop projects.

The work had the additional advantage of involving STEM students from underrepresented backgrounds, for whom the unthreatening, "playful" atmosphere of the interdisciplinary collaborations provides both an entrée to science and scientific questioning, and a sense of the range of applications of STEM fields. Compared to the expense of many scientific undertakings, this new perspective is also replicable across other institutions and internationally, and more cost-effective in the short term.

However, it is sustainable in the long term only with greater institutional support. The inaugural year of the Summer Institute was supported by existing facilities (with broadened access), with some contribution from NSF, NASA, the Packard Foundation, the UCSC Arts Division, and the UCSC Foundation. National and international funding bodies can foster these cross-discipline "transfusions," as Parker calls the benefit researchers receive, by encouraging STEAM projects and tailoring application timelines and requirements to fit. The ultimate benefit is not only to students, and to the public's efforts to understand science, but also to science itself. Working with artists has opened new dimensions, says Ramirez-Ruiz, changing the way he thinks. It changes the way he visualizes scientific phenomena, the ways we arrive at "discovery," and the ways we visualize the world itself.

STEAM Research Perspective 1. OpenLab participant Sudhu Tewari, Ph.D. student, Cultural Musicology, and Mechatronics research member, Digital Arts and New Media program, UCSC

In the past I've been reticent to collaborate with others, with the exception of a few fellow artists for whom I have great respect, a longstanding relationship, or whose skill set fills a gap in my own ability. Even these collaborations with artists I admire and get along with have been difficult; the process of collaboration is not easy for me. Nonetheless, my experience as part of the first OpenLab Summer Institute, working with a team of scientists and artists I had never met before, proved extremely fruitful and not nearly as painful as I had imagined it would be. In fact, I found the experience to be quite inspiring.

A great deal of the success of our project had to do with the nature of our collaboration. Our group – Eric Asphaug, an astrophysics professor, Jennifer Parker, art professor, Noar Movshovitz, astrophysics grad student, Leslie Thompson, art undergraduate art student, Kayla Voung, TASC undergrand CS/Engineering, and myself – worked together in a truly collaborative fashion. Rather than merely looking to one another to fill in gaps in our skill set for a predefined project, we spent a significant amount of time at the beginning of our endeavor discussing our interests and research. As we discussed various aspects of the science, we came up with many ideas about physical objects and visualizations that could be made to embody the scientists' research. Our focus was how such objects or visualizations might allow, or help, these scientists to re-contextualize their research and in doing so, push forward into deeper understanding of their own work or trigger new frameworks/contexts to explore.

It seemed clear to us, the artists, that our greatest contribution to the scientists would be a physical object that, rather than existing as a 2D simulation on a computer screen, allowed them to hold, or see, their research in true three-dimensional space. For me as an artist, it was novel, and quite exciting, to be working with "real" information rather than arbitrary, abstract forms. It seemed clear that our experience, as artists, with physical objects could greatly benefit these scientists, and their understanding of the physical world could greatly inform our practice.

Since working as part of this team, I've become interested in creating meaningful physical forms rather than arbitrarily created "functional" objects. My interest, as an interactive, kinetic, and sound artist, has been, to this point, focused on the functionality of the devices/artworks that I create. Since OpenLab, I've become interested in the meaning that can be made/embedded in physical forms that represent specific pieces of our universe.

In the end, we chose a project that demonstrated a theory cooked up by scientists Martin Jutzi and Erik Asphaug, which attempts to explain why our moon has so asymmetrical a surface. Their theory holds that the earth once had two moons. The smaller moon collided with the moon we know and "splatted" across its surface creating the asymmetrical surface.

The most rewarding part of our collaboration came in seeing Professor Eric Asphaug's excitement as he viewed our three-dimensional stroboscopic zoetrope for the first time. It seemed that he was suddenly able to see parts of the physical equation of the collision he

previously couldn't. It was fantastic to see that our strange amalgam of research and technologies had a purpose (and use!) beyond simply visualizing a theory. Our project was successful in that it was a "true" collaboration: the result was the evolution of a project that neither party (none of the parties!) would undertake, or even conceive of, independently.

In our projects, observations using modern technology resulted in a theory that was tested with a simulation made possible by 21st century software and hardware (additionally, created by scientists working on opposite sides of the globe). This simulation was rendered physical by the hands of an artist, sculptor Leslie Thompson, and turned into a physical animation using a technology that was popular as entertainment in the Victorian era. The end result was a unique device that allowed Asphaug to see his theory for the first time in truly three-dimensional space and even to observe multiple perspectives simultaneously. Our zoetrope also provided a fantastic tool for disseminating Asphaug's research/theory to the general public in an easily graspable, engaging fashion.

The value of encouraging creative thought in those who pursue empirically based knowledge and the value in encouraging empirical and rational thought in those who work in primarily creative fields is becoming increasingly clear. The great leaps forward in both science and art have been made by those who think across the boundaries defined by one discipline and embrace a wide variety of methodologies.

Universities can play a large role in facilitating such fruitful collaborations by encouraging inter-departmental projects and cross-disciplinary research. I would have stayed isolated in the Music Department with no concern for the fantastic scientific research happening a stone's throw from my studio if it weren't for the OpenLab Summer Institute. Bringing together artists and scientists, with the express purpose of creating work collaboratively, provides valuable creative insights that enrich the research of all participants and their fields.

STEAM Research Perspective 2. OpenLab participant James Guillochon, Ph.D. student in Astronomy, University of California Santa Cruz.

My research has focused on what happens when stars come too close to supermassive black holes (SMBHs). Our intention with OpenLab was to create an exhibit that would depict the delicate interplay that occurs between the stars that cohabitate the center of our galaxy with a SMBH. SMBHs are infinitely dense concentrations of matter that reside at the centers of galaxies, and can be as much as ten billion times as massive as our own Sun.

Black holes are usually thought of as huge "vacuum cleaners," absorbing everything and anything. In fact, the gravitational pull of black holes is no stronger than it is for any other matter. If the Sun were instantaneously transformed into a black hole of the same mass, the Earth would continue in its orbit undisturbed, and would not pulled into the black hole any more readily than before the transformation.

The only advantage a black hole has over other kinds of objects is that it has no hard boundary to prevent things from coming arbitrarily close to it. As the force of gravity is stronger the closer one gets to a massive object, this permits the gravitational force very near black holes to become

impressively strong, so strong that the difference in force applied to two sides of an object is strong enough to tear that object apart.

But despite their reputation, black holes have difficulty tearing apart or absorbing anything aside from the ambient gas that permeates all corners of our universe. This is because the distance within which this force is strong enough to be damaging is quite small as compared to the typical distance between stars. The distance between stars is so large that of the 300,000,000,000 stars in our Milky Way today, only around 30,000,000 (0.01%) will be destroyed by the SMBH at its center – or one star destroyed every 10,000 years. The majority of stars that are destroyed reside very close to the black hole, with their destruction being precipitated by random interactions with other stars in their neighborhood.

In our OpenLab team project, we wanted to show what the environment around a SMBH looks like, with thousands of stars directly orbiting the SMBH. We also wanted to show what happens when one of these stars comes too close to the black hole. However, we wanted to emphasize that while the neighborhood around a black hole can be dangerous, the chances of a destructive outcome for any particular star is quite low.

To accomplish this, we combined movies generated using scientifically accurate models of the cluster of stars surrounding the black hole, with other movies produced using hydrodynamical simulations that show the disruption of stars that wander too close. To emphasize the randomness of the process that brings any one star too close to the black hole, we added the ability for users to interact with the cluster directly through the use of a Nintendo Wii gaming system. Users "pitched" stars towards the black hole at the center of the cluster, and if their aim was good enough to place the star on a deeply-penetrating orbit, the star would be destroyed. This mechanism actually closely resembles the actual process by which stars are placed on such orbits: they are "tossed" there by interactions with other stars.

What I learned through this process was the need to compromise between an accurate depiction of reality and the entertainment value of an exhibit. Changes needed to be made to the physical system to make the exhibit more visually appealing, without sacrificing too much of its scientific accuracy. These modifications mostly were changes in scale, both in the distances and in the times over which these interactions take place. Whereas the real system has stars that are one-millionth the size of the complete cluster, the LCD projector we used was only capable of rendering an image with around 1,000 pixels per side. And while any individual star only has a small chance of being disrupted, the chance that we specified in the game cannot be too small, otherwise the exhibit visitors can get frustrated with being unable to disrupt stars. To make sure that users of the exhibit did not take the scales used in the demonstration too literally, we decided to include a monitor that was keyed to display factual information alongside the demonstration itself. This permitted us to have more freedom in our choice of scales, without sacrificing the educational value of the exhibit.

Overall, the exhibit seemed to be successful: it attracted visitors to explore the dynamical environment around a SMBH, and to become more comfortable with the idea that black holes are not as destructive as they are often portrayed to be. The key message that we wanted to convey was "encounters with SMBHs are rare, but when they occur the results are spectacular." We also

wanted to create an exhibit to show that the proper conditions for disrupting stars through their strong gravity are only realized for particular initial conditions (set by the visitors through the Wii controller). Judging by the exuberance and frustration of visitors when they were/were not successful at disrupting a star, it seems we communicated that difficult-to-understand message in this unique, interactive way.

In its value to me as a researcher, the project allowed me to visualize the cluster of stars that surround a SMBH in a completely unique and appealing way, especially considering that usual representations of such systems are through obscure mathematical formulations. The tools I developed to generate the movies for this exhibit will remain useful for talks I give in the future, as I now have a very visually appealing way to share my data and results.

PUBLIC ENGAGEMENT: OpenLab Community Project, Blue Trail

By leveraging the larger communities around her via art/science initiatives, Professor Parker found she could build support in art and science research on campus that also connected faculty and students directly with the public. Currently, OpenLab supports a limited number of affiliate art and science research projects led by faculty, post docs, and graduate students who bring their own funding and resource support (managing these collaborations has fallen to Parker, her Mechatronics research cohort, and her interns).

The most elaborate of the current projects is the research initiative entitled Blue Trail, founded by Lisa Zimmerman of 7Story, a non-profit engaged in public place-making. The project is curated by Laura Cassidy, Ph.D. student in Modern Thought and Literature at Stanford University, and directed by Parker with support from UCSC marine scientists.

Blue Trail is a new STEAM initiative that combines art, tech and ocean science for public exhibition. By expanding to collaborate with other institutions, public and private, international and national, we aim to build bridges for disseminating knowledge to the public and vise versa. These bridges will act as information highways between silos on our own campus, between researchers on other campuses, between professional artists and scientists, between ocean activists and curators, between business associates and public officials, all to create whole-systems thinking that is inclusive of civic engagement for problem solving the issues of our day, such as the health and well-being of our oceans, and other challenges to the environment we live in and depend on.

STEAM Research Perspective 3. OpenLab collaborator and curator Laura Cassidy Rogers, Ph.D. student in Modern Thought and Literature, Stanford University

Of the myriad ways to link art with science, my research explores how experimental media and theory in visual art, design, and technology impact environmental thought. Stanford's interdisciplinary graduate program in Modern Thought and Literature (MTL) has supported scholarship at this intersection of theory and practice since its inception in 1971. More recently, under the direction of Ursula Heise, MTL began to recruit graduate students, such as me, with varying interests in eco-critical research as a means to address complex environmental issues like climate change, water, energy, pollution, biodiversity, and social justice. Upon Heise's departure

for a new faculty position at UCLA, we have reorganized ourselves under the banner of the Environmental Humanities Project (established by Heise in 2007).

As well-documented by research, methods for educating and engaging the public about environmental issues are insufficient. Ecocritical research in environmental humanities is of vital importance to achieving a sustainable future at local and global scales. In particular, bridging art with science, or culture with nature, spurs innovative thinking and problem-solving for ecosystems that are diminishing in health and stability. To this end, I am determined to align my academic research with curatorial projects, working directly with artists and scientists. Some of them are experimenting with new directions in science communication while others challenge the assumptions and conventions of science. Curating is collaborative, hands-on, and place-based, providing an outlet for research while also inviting input from academic colleagues and the public.

In August 2012, I began work with OpenLab, curating a project on ocean sustainability called Blue Trail. Using a two-tiered strategy of offering formal invitations to artists and scientists, and an open-call Design Jam Competition, Blue Trail has assembled a robust cross-institutional network of individuals – artists, designers, techies, scientists, and volunteers – who are passionate about responding locally to the global challenge of sustaining the world's oceans. Specifically, it seeks to form a temporary "trail" of 10 interactive installations along the San Francisco waterfront in September 2013.

Over the course of the coming year, I will work with all these individuals to form teams and develop proposals for installations that combine art, design, technology, and marine science. These installations will examine topics ranging from the accumulation of plastic marine debris and other byproducts of the global economy such as pesticides and ocean acidification; resource depletion and food systems including agriculture and aquaculture as they affect the oceans; and, variations on marine biodiversity ranging from species extinction to species migration and the ecological effects of sea level rise caused by global warming.

In the first stage of the project, we received 30 sketch proposals from individuals primarily in the San Francisco Bay Area, with a handful of submissions from the Eastern Seaboard (Boston and New York City) and one from an artist based in Madrid who connected to Blue Trail while in residence at the Montalvo Arts Center near San Jose. Our next step is to gather a jury of interdisciplinary leaders to help select 10-15 of the sketch proposals to revise as final proposals that address specific sites along the San Francisco waterfront.

Ultimately, Blue Trail is a project about connectivity. If successful, it will form a series of temporary, interactive installations to engage the public in ocean sustainability. It will capture their attention in the moment of interaction – whether physically walking along the San Francisco Bay or virtually surfing Blue Trail on the worldwide web – and it will sustain that attention, moving from engagement to awareness to action. We are working collaboratively to experiment with tools that allow people to navigate our blue planet, with the water cycling from the mountains to the sea, situating themselves as agents in dynamic earth systems as they unfold. However, given the steep fundraising challenge to realize Blue Trail in its full capacity – it is a non-profit with pro bono staff and volunteers – we are uncertain about the exact outcome in

September 2013. Already, though, Blue Trail has succeeded to inspire and innovate for ocean sustainability by establishing a cross-institutional network and gathering a cross-disciplinary set of proposals.

Experimentation is needed to boost civic engagement in a sustainable future. Rather than telling people what to do, Blue Trail installations will ask them, what would you do? Integrating art with marine science will both deepen and expand the potential for innovative possible solutions to arise, as we work within and across disciplines, and with the public, to achieve a sustainable future.

SUGGESTED ACTIONS

Given the initial success of these projects:

1. That National Academies, Administrators at Educational Institutions, and Funders prioritize support for Art/Science centers like OpenLab, as interest and demand by faculty and students across campus is increasing and shows enormous potential both for new discoveries and significantly improved public outreach.

2. That Universities provide larger permanent spaces on campus to foster STEAM learning opportunities through project-based initiatives that are developed and supported.

3. That Universities and Funders support creation of Art and Science Studio Research Associate positions to manage facilities and support STEAM research projects.

4. That Universities and Funders support increased administrative and outreach support for art/science collaborations to manage the demand for participation and public engagement.

5. That these same groups develop professional ways to support cross-disciplinary research, which is currently verbally encouraged but not supported; faculty and graduate students can be penalized if they step too far out of their research foci. This needs to reworked to support research that includes hybrid practices, co-teaching, and opportunities for migrating and sharing resources with arts and sciences majors that are inclusive, to create meaningful intersections between all the other disciplines on campus.

6. That Funders prioritize grants for STEAM case studies to better understand, define, and assess the collaborations of artists and scientists, and that permit arts-based researchers to be PI's alongside their science counterparts.

7. That Artists, Scientists, Designers, Scholars, Engineers, and their Professional Associations, as well as Universities, Industry, and Funders develop guidelines to value and prioritize collaborative research as crucial to future innovations.

Fragments /Examples on Science / Art / Collaborations and the Local / Social / Personal Context

Coordinator: Miklós Peternák

Semantic Proposal

Renewal of existing structures and classification: the structure and scientific classification of the academy goes back worldwide mainly to the XVII-XIX centuries, with some artistic roots. Due to the swift development and proliferation of scientific disciplines the scientific component of these bodies became ever stronger, while art almost disappeared. There were several attempts to (re)integrate art into these societies, but without success. Either it was only symbolic or, as recently in Hungary, it led to a creation of a certain "Art Academy" as a representational body – with no discernible sense. Academies should revise their existing division systems overall, and create a new division, not for art in general, but specifically for experimental art and artistic research.

Funding

Applied scientific research can turn to any number of sophisticated funding bodies and resources. Artistic research has no established and publicly accessible funding structures. In recent decades several universities have established doctoral schools in the arts offering the PhD/DLA degree. The experiences and effects of these schools could probably provide guidance regarding why and how to create permanent funding for experimental art and artistic research.

Institutions

The first half of the 1990s was a time of new media institutions, with several innovative types of interdisciplinary media center established worldwide. During the last ten years these institutions, using diverse survival strategies, have transformed themselves either towards sizable "industries" of festival- and exhibition-making, or became small-scale NGOs and sometimes disappeared from lack of resources. In any case the innovative, creative character of the initial period was lost or survives only at the applied, profit-oriented level. All the same, contemporary technical developments in all fields allow for a certain reestablishment of such centers, most effectively as a joint institute of universities or other institutions of higher education.
Education

With the computer a new type of literacy arose. This fact is not reflected in education systems (or insufficiently so).

Survey

International, comparative, transdisciplinary research is called for, to explore the production and results of experimental art practices over the last 100 years, as well as the rapid and radical changes in technology from the invention of the first technical image — photography — and the first telecommunications tool, the telegraph.

Increasing K-12 Student Science Engagement And Learning Through Integrating Mandated Content with Innovation Thinking Skills

http://wp.me/P2oVig-nZ

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ABSTRACT

According to a number of nationally-recognized researchers, authors, educators, businesses, governmental panels, and studies, the United States' future place in the global economy could be significantly impacted by the degree to which today's students are taught to think innovatively (Friedman, 2009, 2011; Florida, 2003; Robinson, 2011; Zhao, 2009; President's Council of Advisors on Science and Technology, 2010; National Science Board, 2010; Gardner, 2008; Bransford, 2000; Lemelson-MIT, 2003). They point out that, in order to be competitive in this rapidly-changing world, students in all demographics must learn to integrate vital 21st century innovation thinking skills with science, technology, engineering, and math (STEM) learning.

These thinking skills include: conceptual and visual/design thinking, creative and critical thinking, problem-finding and problem-solving, collaboration, and communication. The integration of these skills with science, technology, engineering, and math concepts promotes students' abilities to problem-solve and design innovative solutions. (Starko, 2003; Cropley, 2003; National Academy of Sciences, 2002; P21, 2012).

While teaching the mandated standards in the current test-driven education environment is very important, it also is vital to develop ways to integrate these important innovation thinking skills with the mandated, standards-based learning (National Education Association, n.d.). Although the current test-driven culture provides some roadblocks, it also provides opportunities to develop ways to deeply integrate these vital thinking skills with content delivery. Opportunities

include: state, national, and international collaborations among institutions, disciplines, and forms of content delivery. These integrated disciplines include the fine arts, science, technology, engineering, language arts, math, and humanities. Forms of delivery can include the integration of formal and informal education methodologies with higher education and technology partners. Successful integration of these disciplines and approaches in this white paper's authors' work offers interesting opportunities for further exploration. These help inform the paper's concluding calls for action.

INNOVATION ECONOMY AND EDUCATION

Defining Creative and Innovation Thinking

While the terms creative and innovation thinking are widely used, it is important to relate and distinguish the two. For the purposes of this paper, the approach developed by one of the world's leading scientific experts on creativity, R. Keith Sawyer, will be used. He points out that individual creativity is a new mental combination of thoughts that are communicated (Sawyer, 2012). He adds that innovation is the development of a product that is judged to be novel, appropriate, useful, or valuable by a knowledgeable group (Sawyer, 2012).

The Need

Global Need: According to a number of authors and studies, a nation's success in today's growing global economy will depend on its ability to innovate (Friedman and Mandelbaum, 2011; Robinson, 2011; Florida, 2003; President's Council, 2010; National Academies of Science and Engineering, National Institute of Health, 2010). For example, renowned international author and education advisor Sir Ken Robinson points out that, in the current social and economic revolution, governments, companies, and many other entities are emphasizing the essential need for creativity and innovation thinking. He adds that the global culture that most effectively trains its students to process information innovatively will be the dominant culture (Robinson, 2011). This phenomenon is driven, according to acclaimed economics authors Thomas Friedman and Michael Mandelbaum, Ph.D., by globalization and the technology revolution. Friedman and Mandelbaum add that education is now an economic issue, making it imperative that education systems integrate creative/innovation thinking with the mandated basics (Friedman and Mandelbaum, 2011). Additionally, a 2011 General Electric survey of 1,000 business executives in 12 countries found that 92% of the executives believed that innovation is the main driver of a competitive national economy (General Electric, 2012).

National Need: Sir Ken Robinson's assertion that a nation's position in the global economy will be influenced by its ability to innovate (Robinson, 2011) is echoed by the National Science Board in the U.S. It emphasizes that the US needs STEM innovators (National Science Board, 2010). This is echoed by a 2010 report generated by the presidents of the National Academy of Sciences, National Academy of Engineering, and National Institute of Medicine, which states that for the US to remain economically competitive, it must generate scientists and engineers who can produce "creative, imaginative, leading-edge work", in short, innovation. (National Academy of Sciences, 2010). Additionally, the President's Council of Advisors on Science and Technology points out that science, technology, engineering, and math (STEM) education will

determine whether the US remains an international leader (President's Council of Advisors on Science and Technology, 2010).

Prominent sociologist Richard Florida concurs that creativity is a key factor in a nation's economic success (Florida, 2003). Also, a report by the international business and research association, the Conference Board, working with the American Association of School Administrators and Americans for the Arts, found that 99% of US superintendents and 97% of US business executives rated creativity/innovation of increasing importance. These respondents concurred that education plays an important role in preparing the future innovation workforce. However, the study found that 85 % of business executives were having trouble finding the qualified innovation-thinking applicants (Lichtenberg, 2008).

Add to these mandates the need for international cooperation. Friedman advocates for global absorption of best practices and tolerance, pointing out that the global advantage will go to cultures that cooperate internationally. Friedman also suggests that today's education should include training in the ability to think and cooperate internationally (Friedman, 2005). A case in point is the NASA Jet Propulsion Lab's successful landing of the latest Mars Rover, Curiosity, which was designed, built, and landed with international cooperation. Additionally, Curiosity's development was driven by creative and innovation thinking, especially the Entry-Descent-Landing phase. According to the Jet Propulsion Lab's Imagine Mars Project Lead, David Delgado, "Landing a rover of that size and weight had never been done before and it required a completely new approach to solving the problem. It is this type of problem that requires the utmost of creativity because relying on the conventional approaches can't be relied upon. This creative/innovation thinking is what we share with today's students through the Imagine Mars Project. We take some of the same real world problems that engineers and scientists are challenged with at JPL and give them to the students, like developing solutions for human habitation of Mars. With these types of challenges, both critical thinking and creative thinking are crucial. It is vital that today's students learn to think creatively and innovatively so that they have the tools to take on the most demanding challenges in their future."

Problems in Meeting the Need

Roadblocks: There is currently a diminished interest in STEM among US students, in addition to a lack of innovation thinking skills to prepare the future innovation economy workforce (President's Council, 2010; Bronson and Merryman, 2010)

STEM Innovation: The President's Council of Advisors on Science and Technology points out that: 1) less than 1/3 of US eighth graders demonstrate science and math proficiency on the National Assessment of Educational Progress test; 2) there is a pervasive lack of student interest in STEM; 3) many of the most STEM-proficient students are choosing careers other than science and engineering; and 4) STEM teachers are often inadequately engaged or prepared (President's Council, 2010). Additionally, education researcher Yong Zhao, Ph.D., says that while the US has led the world in innovation, other countries such as China are working feverishly to catch up and, if US education continues on its current trajectory, will pass the US. For, China has foregone its linear, fact-based education system for one that is promoting creative thinking, where the US is foregoing creative thinking in favor of a linear, fact-based education (Zhao, 2009).

Creative/Innovation Thinking: Po Bronson and Ashley Merryman, in their famous Newsweek article, "The Creativity Crisis", demonstrate that American creative thinking, a predictor of adult innovation thinking skills, has been on the decline since 1990, while other countries are increasing their creative capacity (Bronson and Merryman, 2010). They are seconded by Newsweek's Michael Hirsch, who states that the US is now ranked the number 11 nation among Newsweek's best countries of the world. Hirsch cites Education Secretary Arne Duncan, who states, "The country that out-educates us today will out-compete us tomorrow." (Hirsch, 2010). He also cites a recent McKinsey and Co. study which showed that the growing education gap between the US and other leading countries could impose the "economic equivalent of a permanent national recession" (Hirsch, 2010). An MIT report on inventiveness additionally points out US education's need for open-ended problem-solving, self-discovery, visual thinking, and learning from failure (Lemelson-MIT Program, 2003). However, teachers with whom we work often report that their students are afraid to take risks for fear of failure or because the challenge seems too great. They also point out that in today's education environment, students have more trouble thinking visually and solving problems in a cross-curricular fashion due to lack of experience in those innovation thinking skills. They also site lack of time in the tightly-packed school curriculum schedule to work on innovation thinking skills.

Some Suggested Solutions for Meeting the Need

Science, Technology, Engineering, and Math (STEM): A number of skills and strategies have been suggested to address these creative/innovation thinking needs. The National Science Board recommends: 1) fostering such innovation thinking skills in students as engagement, curiosity, and creative problem solving; 2) engaging talent from all demographics, including underrepresented minorities and students from low-income families; 3) encouraging partnerships between such groups as K-12 schools, businesses, content developers, and researchers; 4) providing an environment that celebrates creativity and innovative thinking, regardless of demographics or geographic locale (National Science Board, 2010). The President's Council of Advisors on Science and Technology additionally recommends that students gain conceptual understanding and procedural fluency in addition to the science facts. That means that they must develop a deeper understanding of science concepts, integrating concepts across disciplines through the scientific processes. Specific Council recommendations include individualized and group experiences outside the classroom, such as after-school and extended-day programming. (President's Council, 2010). This is reinforced by the new Next Generation Science Standards, which focus on integrating scientific concepts, along with math and language arts, and applying these, especially in engineering. (National Research Council, 2012). Renowned education expert Howard Gardner, Ph.D., points out that synthesis is one of the most important thinking skills for this century. He adds that two effective strategies for achieving these skills are the use of metaphors, images, themes, and the use of works of art. He promotes the integration of disciplines in which the disciplines are not just juxtaposed, but are "genuinely integrated". This integration, he states, should provide an understanding that could not have been achieved by either discipline alone. He also promotes multiperspectivalism, pointing out that viewing a problem from different perspectives can lead to a more effective solution (Gardner, 2008).

Creative/Innovation Thinking Skills: From their research, Newsweek's Bronson and Merryman point out that the ability to integrate concepts is crucial, especially using this skill in the divergent/convergent thinking of creative problem solving and design thinking. They also point out the important relationship of play with creative thinking (Bronson and Merryman, 2010). Friedman and Mandelbaum concur, stating that what is important today is students' effectiveness at problem-solving, using creative and critical thinking. This is what will promote any nation's innovation capabilities and leadership in the global economy, they add (Friedman and Mandelbaum, 2011).

Creative/Innovation Thinking Skills in Education: MIT calls for an "infusion of inventive creativity into the K-12 education" (Lemelson-MIT Program, 2003). Strategies that they include are: visual thinking, hands-on learning, experiential problem-based teacher workshops, research on the creative mind and how people learn, and a sharing of information between schools and universities (Lemelson-MIT Program, 2003).
Creative/innovation thinking skills considered important in education also have been addressed by noted researchers such as Howard Gardner, Alane Starko, A.J. Cropley, and Arthur Costa. These important skills include: inquiry-based learning, conceptual integration, knowledge transfer, collaboration, communication, arts/design thinking, problem-finding/problem-solving based on real-world problems, persistence, flexible thinking, learning from failure, metacognition. Other important thinking skills include: visual thinking, inventing, play/tinkering, and emotional engagement (Costa and Kallick, 2009; Cropley, 2003; Gardner, 2008; Starko, 2005; Wiggins, Grant and McTighe, 2006).

Additionally, The National Advisory Committee on Creative and Cultural Education (NACCE) study in the United Kingdom, chaired by Sir Ken Robinson, found that all children can benefit from developing their creative thinking skills. This should be a focus of education, the study stated. It also found that creativity can be developed in all areas of the curriculum, in the sciences as well as the expressive arts. Additionally, this extensive study discovered that students can demonstrate creativity in the sciences and problem solving, as well as in music and fashion, language, designing and making, and manipulating numbers, and that some students may not be creative in one domain but show creativity across the curriculum. Approaches that it associated with creative thinking were: brainstorming, designing and making, solving problem, seeing links and connections, expressing perceptions, failure and perseverance, and collaboration (HMIE, 2006).

Knowledge Transfer and Problem-Based Learning: Knowledge transfer and problem-based learning are vital aspects of creative/innovation thinking in education that can address a number of the skills addressed above (Wiggins and McTighe, 2006). These skills have been addressed by educators and by science researchers. The Next Generation Science Standards emphasize the importance of applying crosscutting science concepts and engineering design to real-world applications (National Research Council, 2012). Knowledge transfer, in which crosscutting concepts can be integrated, is a central aspect of the Understanding by Design model promoted by Grant Wiggins, Ph.D. He points out the importance of students' ability to adapt and transfer knowledge to the needs of the situation or the problem (Wiggins and McTighe, 2006). This model is supported by education researcher John Bransford, Ph.D., who applies this technique to STEM in pointing out that, due to the exponential increase in information, it is not as important

for children to learn facts, as it is for them to learn to process this information, to make connections between ideas, and to organize the ideas around central concepts. Transfer of knowledge between modalities is essential, he says (Bransford, 2000). A National Academy of Sciences study concurs, pointing out that "Learning with understanding is facilitated when new and existing knowledge is structured and around the major concepts and principles of the discipline" (Gollub, 2002).

This knowledge transfer includes transfer between STEM and art modalities. Walter Massey, former Director of the National Science Foundation and currently President of the School of the Art Institute of Chicago, points out that one must move beyond the superficial integration of the arts and science, beyond the aesthetics and artifacts, into developing the processes that the two disciplines share, such as the importance of failure and of creative thinking and problem-solving. The arts, he says, are integral to the innovation ecosystem (Massey, 2011).

Arts Education and Content Learning: According to noted creativity researcher R. Keith Sawyer, arts education can provide unique habits of mind that may facilitate learning in other content areas. He additionally points out that when the arts are integrated with learning in other content areas, learners acquire a deeper understanding and an ability to think more flexibly using content knowledge. They also develop enhanced critical thinking and creativity, he points out (Sawyer, 2012). Particular habits of mind developed in arts education that could be studied for learning transfer include the ability to observe, envision, express, reflect, explore, engage, persist, and develop craft (Hetland et al, 2007).

Additionally, noted innovation expert Sir Ken Robinson points out that, in order to promote creative abilities, school systems throughout the world must achieve a balance between the emphases on science, technology, mathematics, and language arts and the fine arts, humanities, and physical education. He points out that each of these disciplines reflects major areas of cultural knowledge and addresses a different type of intelligence and creative thinking, thereby increasing the capacity to reach a variety of learners and develop important innovation thinking skills (Robinson, 2006).

Arts Education and Content Engagement: A study by the Chicago Arts Partners in Education found that after arts-integrated units, students showed increased interest in the content subject matter, offering the possibility of an effect on students' cognitive growth over time, the study reports (DeMoss and Morris, 2002, in Burnaford, 2007). Additionally, arts integration research in A+ schools in Oklahoma found such effects as higher student achievement, better attendance, and decreased discipline problems (Barry, 2003, in Burnaford, 2007). A meta-analysis conducted by the renowned Critical Links study found that there is evidence for links between arts experiences and affective development driven by the interaction of physiology, cognition, and behavior (Deasy, 2002, in Burnaford, 2007). Can similar effects be found through the integration of the arts and STEM? This is a fertile area to investigate.

Visual Thinking: According to Sir Ken Robinson in Out of Our Minds: Learning to Be Creative, scientists, like artists, often extensively use visual imagery in both formulating and expressing their ideas (Robinson, 2006). Exploring the transfer of these abilities to enhance of both visual art and science skills is another vital area of investigation.

Arts Integration: There have been a number of studies looking at the impact of arts integration on student achievement in formal education. However, there appears to be a lack of studies investigating the impact of the arts on science engagement and learning and the attendant innovation thinking in STEM, especially cognitive transfer (Burnaford, 2007).

INTEGRATING INNOVATION THINKING AND MANDATED STEM LEARNING: APPLICATIONS AND FINDINGS

Partnerships and Projects: ICEE Success and its state, national, and international partners have developed partnerships and projects that address the above-stated needs, problems, and recommendations. These projects integrate innovation thinking with mandated STEM learning concepts using both formal and informal learning strategies in K-12 classrooms and teacher professional development. They integrate partners from higher education, K-12 education, informal learning, the tinkering movement, NASA, business, science, engineering, technology, and the arts statewide, nationally, and internationally. Data shows that there is merit in further studying the success of these partners' strategies. Below are listed representative applications, findings, and participant comments.

A STEAM State Partnership: In Texas, ICEE Success and its partner, SITE (Success through Innovation Thinking in Education) pilot a number of projects across the state to develop and research the intersection of STEM and innovation thinking in classrooms and teacher professional development. SITE is a partnership between ICEE Success, the Exploratorium's MIT-originated Playful and Inventive Exploration (PIE) project, and a consortium of science education partners at Rice University, Southern Methodist University and the University of Texas at Austin. Primary project advisor is Mary Hobbs, Coordinator for Science Initiatives at Texas Regional Collaboratives for Excellence in Science and Mathematics, University of Texas at Austin. She says, "The call from business and industry seems clear—that in order to be economically competitive, the U.S. has to educate its young people to be problem solvers and creative thinkers."

Linda Scott, Ed. D., SITE Rice Center Director and Executive Director, School Science and Technology, Rice University, and former Director of Intermediate Science at Aldine (TX) ISD agrees. She says, "Mandated testing in Texas has caused test performance to become the measure of a successful district, school, and classroom teacher. This climate has elevated student performance on tests as the major driver of what is delivered in classrooms across the state of Texas. Teachers have no creativity in what must be taught in their classrooms; they must effectively teach the state standards. However, teachers do have creativity in the way in which they deliver the state standards in their classrooms to their students. Our district was searching for a research-based vehicle that would allow us to teach the mandated state standards and, at the same time, highly motivate both our science teachers and our students. Our research led us to offer professional development in innovation thinking integrating science and art. We made the decision to pair our intermediate science specialists and art specialists for a series of professional development activities. The science specialists learned that the world of art had much to offer them, including a way of thinking visually that transformed how science teaches observational skills and a way of thinking that made problem-solving fun. They found that art-science

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integration added strength to their science lessons, and developed a deep appreciation for the art teachers' depth of science content in their areas of expertise. The art specialists were equally surprised to find that integrating science content and art lessons strengthened both disciplines and they found themselves included as a core content area. The collaboration between science and art teachers produced increased student motivation and content retention over time."

Arts/Science Teacher Professional Development: In addition to working with students, partners developed strategies for effectively training teachers in the integration of innovation thinking and required student learning. Dara Williams-Rossi, Ph.D., Southern Methodist University Assistant Clinical Professor in Science Education and Director of Undergraduate Programs, reports, "In partnership with ICEE, Southern Methodist University provided over 40 hours of professional development that intersects art and science. K-12 science teachers utilized arts/design and playful and inventive exploration (PIE) techniques to help their students more deeply understand science content. A majority of the teachers began to utilize these techniques in their own classrooms. One teacher who participated in the professional development explained how she implemented these strategies: 'Working in science stations, we build our background knowledge and then applied it by answering a challenge through creativity. Overall, I have observed greater [student] understanding in the content taught, and this shows though assessment'. Preliminary data collected during the professional development activities suggest that the science teachers not only now see the important connections between science and creativity but are also successfully utilizing the practices to engage and enrich their students.

This further supports the idea that changing teacher beliefs changes their practices." Data collected during the professional development suggests that the science teachers saw that integrating the mandated concepts with creative/innovation thinking could promote science engagement and understanding. For example there was a 26% increase between the first and last sessions in the number of teachers who indicated the highest level of agreement with the statement that integrating the standards with the problem-solving and inventing would engage the students in the science standards. There was a 31% increase in the number of teachers with the highest level of agreement with the statement that these strategies could help the students better understand the science concepts.

NASA/Jet Propulsion Lab's Imagine Mars Project: In partnership with the Jet Propulsion Lab, NASA's Mars formal education center at Arizona State University, the Exploratorium's MIT-originated Playful and Inventive Exploration (PIE) project, the Center for Earth and Space Science Education planetarium, and local school districts, ICEE uses innovation thinking to promote student engagement and learning in science and language arts. Students perform grade-level hands-on investigations of Earth, physical, and life science, often trained in design thinking by their art specialist, then problem-find, design, and build solutions to human exploration of Mars, using mandated content, innovation thinking skills, the fine arts, and technology. NASA's Imagine Mars Lead, David Delgado, says, "We have seen unengaged students become very excited about science, design, and creative thinking as a result of Imagine Mars. They have shown a new ability to think innovatively, demonstrated greater self-efficacy in STEM and 21st Century Skills, as well as shown a new interest in STEM related learning."

Results include the following: 1) In Tyler (TX) Independent School District: At Caldwell Elementary Arts Academy (65.0% Economically Disadvantaged; 53.9% At-Risk), a 5th grade teacher said, "Imagine Mars is the 'glue' that makes the concepts stick in the students' minds. This is what school should look like"; at Orr Elementary (89.4% disadvantaged; 86.2% at-risk), students scored the highest science passing rates of any elementary in district in the targeted student sub-population, African Americans, after their 5-session Imagine Mars experience. Orr principal Walter Perez said, "Imagine Mars has had a significant impact on our students. I have been involved with this project for a number of years, and can verify that these programs significantly contribute to my students' science engagement and learning. Not only were the students learning; they also were engaged in the science content to create their standards-driven Mars inventions." 2) In Palestine (TX) Independent School District's middle school (71.2% Economically Disadvantaged; 56.8% At-Risk), the 88 8th graders involved in the Imagine Mars project scored 12% higher on the science benchmark test taken during that period than the 88 students who were not involved in the project. In the Imagine Mars treatment class, passing benchmark test scores for the Hispanic sub-population rose 10% after the innovation thinking experiences. Principal Larissa Lovelace commented, "It has definitely increased interest in STEM, especially among low-performing students who have not been engaged. Some of them ended up taking leadership roles in their inventing teams… This could help retain students who might be at-risk for dropping out." A middle school student remarked, "You have to think about your concept many times in order to solve it, and that helps you remember it".

In Aldine (TX) Independent School District, the integration of innovation thinking skills and mandated science concepts was applied to a 3-day side-by-side training of art and science specialists. As a result of this training, participating science specialists showed a 66% increase in willingness to use problem-based learning and an 83% increase in understanding of the importance of integrating science and art in their curriculum.

Integrating STEM with Art Museum Programming: A multi-year partnership between the National Museum of Women in the Arts in Washington, DC, ICEE Success, and SITE explored the deep integration of visual and creative thinking with standards-based science and language arts learning in the ABC Picks Up STEAM project. In this project, students first analyzed the science content in an image from the museum's collection. They then integrated mandated science concepts to design a paper-engineered book that could even be driven by circuits. They also wrote about their integrated science concepts. In data from 200 students in 2 geographically diverse 5th grades in Title I schools, there was an 87% increase in the question "Making 3D book art helps me better understand science" after the experience. Teacher comments included, "It was important to see the students looking for connections between concepts and writing about them, then problem-solving to create the 3D books." In fact, this project was particularly effective with English Language Learners. A bilingual teacher reported, "Students made connections by themselves during the visual thinking. It was amazing how students were able to recognize science concepts everywhere they looked during this activity." National Museum of Women in the Arts Director of Education Deborah Gaston pointed out the value of equally integrating visual art and science She pointed out, "We developed the ABC curriculum to integrate the visual arts and languages arts, to draw direct parallels between the creative processes and tools of artists and writers. It's a natural and important extension of ABC's original goals to draw similar parallels between the creative thinking of artists and scientists. It's particularly gratifying that student learning is taking place in the arts as well as in science. Too

often the visual arts are put in service to other subjects; this project values the arts equally, by encouraging students to recognize connections between the arts and sciences." Science education professor and SITE project participant Dara Williams Rossi, Ph.D. said, "Creative thinking leads to innovation in science and many other fields, for that matter. Because artists and scientists use some of the same techniques, such as experimentation, observation and problem- solving skills, the integration of art and science is a natural fit that promotes creativity."

Integrating Art and STEM in an International Partnership: A partnership between the Canadian Philip Beesley Hylozoic Ground project, The Leonardo art/science museum in Salt Lake City, Utah, faculty at the University of Waterloo's Centre for Knowledge Integration (CKI), and ICEE Success, is exploring the impact of innovation thinking on mandated science content engagement and understanding. This project invites students to integrate cutting-edge exhibit concepts with cross-disciplinary experiences in science, engineering, art, and design to solve a real-world problem. The students use shape memory alloy (muscle wire), motors, and found objects to create a kinetic device that demonstrates the interrelationship between forces/motion and other science concepts. Although data is still being collected, Lisa Covington, the Palestine (TX) ISD science lead for 6th through 8th grades, said that the 7th grade students who participated in this project were "extremely engaged in the science and engineering and excited about designing their solutions and taking it into other applications in their own lives." Exhibit engineer, Associate Professor at the University of Waterloo's Centre for Knowledge Integration, and project collaborator Rob Gorbet, said that "the hands-on problem-solving activity coupled with mandated science concepts provides an important opportunity for the students to see the relevance of science in their daily lives, and to make the connections across the disciplines of science and art which are crucial for creative, innovative thinking."

This integration of mandated science concepts and innovation thinking is also evident in museum experiences. This extensive exhibit made its US appearance at The Leonardo in Salt Lake City. Leonardo museum director Alex Hesse points out that this exhibit promotes students' integration of science and innovation thinking. She says, "The Leonardo utilizes the Philip Beesley installation as a natural hook for engaging students in interesting interdisciplinary connections through an in-depth student workshop that focuses on perspectives. This workshop involves students and teachers in an educational, enjoyable, and comprehensive experience designed to foster knowledge, conceptual understanding, and curiosity. It immerses students in experiences that blend science, engineering, technology and art, while integrating critical skills of creativity, innovation, problem solving, communication and collaboration. The workshop's objectives include not only increasing understanding of the process and practice of science, along with the mandated state science concepts, but also encouraging a sense of curiosity that can stimulate further explorations. Students observe, express, envision, reflect, explore, engage, design and persist as they explore the installation from a variety of perspectives. The students discover how responsive architecture more closely integrates symbiotically with its environment and responds to that environment; they create blind-contour drawings of components within different layers, analyze these components structurally and functionally (down to what is happening at the molecular level in the memory metal Nitinol), consider alternate applications for components beyond this installation, and ultimately apply their understanding to design a collaborative "living" installation that completes a repeatable task with the single pull of a string."

HOW BRAIN RESEARCH SUPPORTS THESE FINDINGS

Brain-based research shows that applying concepts to multiple modalities enhances a student's ability to retain the information. For example, Ken Wesson, Ph.D., lecturer on the neuroscience of learning, points out that the brain retains information more effectively if it is emotionally engaged and if the information is repeatedly applied to multiple modalities, as in the concept integration strategies (Wesson, 2002). Education researcher John Bransford, Ph.D., points out that effective learning requires information processing, forging connections between ideas around a central concept, and transferring information among different modalities (Bransford, 2000). Paula Lundberg-Love, Ph.D., Professor of Psychology at the University of Texas at Tyler, referencing Neil R. Carlson's Physiology of Behavior (Carlson, 2012), a neuropsychology textbook, points out that when facts are used in other contexts, brain synaptic strengthening occurs, helping students remember what they have learned. The New York Times article, "Forget What You Know about Good Study Habits", (Carey, 2010) references several studies that indicate that the brain better retains information when it is applied to a variety of contexts over time and is learned in differing environments. Thus, applying mandated science concepts to multiple modalities, such as the arts, design, and engineering, could enhance understanding and retention.

SUMMARY: FURTHER IMPLICATIONS, BROADER IMPACTS

Experts and studies point to the crucial need to integrate vital innovation thinking skills with mandated science content learning in K-12 education environments. Suggested strategies exist to accomplish this. State, national, and international partnerships are exploring these needs and these strategies through pilot projects. They are generating promising initial data. This data and observations suggest that integrating innovation thinking with mandated content learning promotes science engagement and learning, especially in underrepresented populations. This information can help fuel studies and policies that determine and implement the most effective practices in these fields.

SUGGESTED ACTIONS

Suggested Action #1: K-12 Policy Changes

Stakeholders: Education policymakers (national and state legislative bodies, state and regional education agencies)

The Need: Classroom curriculum and mandated tests don't address vital innovation thinking skills needed for national and global economic success.

The Opportunity: Become a primary catalyst that fuels the national and global economies while increasing student content engagement and learning.

Suggested Actions: Enact policies that place equal emphasis on innovation thinking skills and content learning. Promote and fund the cross-disciplinary integration of arts and design thinking skills, mandated science, math, and language arts standards, and problem-based learning with

global outreach to partner with students in other nations. This can be accomplished through teacher education, workshops, grants, research, and the development of a national K-12 Innovation Thinking Center. This Center would direct, promote, and assess the delivery of these skills.

Suggested Action #2: K-12 Curriculum Changes

Stakeholders: State education agencies and school districts

The Need: K-12 curriculum does not include vital innovation thinking skills.
The Opportunity: Develop and evaluate K-12 curriculum that provides the next generation of innovation thinkers.

Suggested Actions: Design curriculum that promotes innovation thinking skills while delivering mandated content. Important components of this curriculum are: knowledge transfer among all fine arts and core disciplines, problem-finding /problem-solving, collaboration, persistence, learning from failure, arts thinking, thinking flexibly, inventing, tinkering, and emotional engagement. Engage experts in these fields to assist in the curriculum development. Research and evaluate the most effective strategies as they are developed.

Suggested Action #3: Research

Stakeholders: Federal and state agencies, private funders

The Need: There is a great lack of quality research documenting the impact of arts and innovation thinking skills on science and math engagement, learning, and pipeline attitudes. There are proof-of-concepts models that need to be explored, scaled, and evaluated to determine effectiveness.

Opportunity:

Suggested Actions: Provide funding to comprehensively evaluate proof-of-concept and best practices models to determine the most effective arts/science strategies that promote innovation thinking, in addition to STEM engagement and learning. There should be additional funding for further development of assessments of these skills within the mandated testing cycles.

Suggested Action #4: Funding for Innovation Thinking in K-12

Stakeholders: Governmental and private funders

The Need: Innovation thinking skills in the US are on the decline, affecting business and the US economy. There are funding opportunities for innovative approaches, but there is a need for funding that directly addresses delivering innovation thinking skills within the public K-12 mandated curriculum.

The Opportunity: Become the driver behind the innovation thinking surge in K-12 education.

Suggested Actions: Work individually and in partnerships to provide funding and incentives to increase innovation thinking skills in K-12 students. This includes funding for: curriculum development and evaluation, program development that partners formal and informal education, business, and higher education, and strong assessments.

REFERENCES

Bransford, J., M. S. Donovan, and J. Pellegrino. (2000). How people learn: Brain, mind, experience, and school: Expanded edition. Washington, DC: National Academy Press.

Bronson, P. and A. Merryman. (2010, July 10). The creativity crisis. Newsweek. Retrieved from www.thedailybeast.com/newsweek/2010/07/10/the-creativity-crisis.html

Bunaford, G. and S. Brown, J. Doherty, and H.J. McLaughlin, Ed. (2002). Critical links: Learning in the arts and student academic and social development. Washington, DC: Arts Education Partnership.

Carey, B. (2010, September 6). Forget what you know about good study habits. New York Times. Retrieved from http://www.nytimes.com/2010/09/07/health/views/07mind.html?pagewanted=all&_r=0

Carlson, N. (2012). Physiology of behavior. 11th ed. Upper Saddle River, NJ: Pearson

Costa, A.L. and B. Kallick. (2008). Learning and leading with habits of mind: 16 essential characteristics for success. Alexandria, VA: Association for Supervision and Curriculum Development.

Cropley. A.J.. (2003). Creativity in education and learning: A guide for teachers and educators. NY, NY: Routledge Farmer.

Erickson, H. Lynn. (2007). Concept-based curriculum and instruction for the thinking classroom. Thousand Oaks, CA: Corwin Press.

Friedman, T. (2007). The world is flat: A brief history of the 21st century. NY, NY: Picador/Farrar, Straus and Giroux.

Friedman, T. and M. Mandelbaum. (2011). That used to be us: How America fell behind in the world it invented and how we can come back. NY, NY: Farrar, Straus and Giroux.

Florida, R. (2003). The rise of the creative class and how it's transforming work, leisure, community, and everyday life. NY, NY: Basic Books.

Gardner, H. (2008). 5 minds for the future. Boston, MA: Harvard University Press.

General Electric. (2012). GE global innovation barometer: Global research report. Retrieved from http://files.gecompany.com/gecom/innovationbarometer/GE_Global_Innovation_Barometer_Report_January_2012.pdf

Gollub, Jerry P., Meryl W. Bertenthal, Jay B. Labov, and Philip C. Curtis, Eds. 2002. Learning and understanding: Improving advanced study of mathematics and science in U.S. high schools. Washington, DC: National Academies Press, 118.

Her Majesty's Inspectorate of Education (HMIE). (2006). Emerging good practice in promoting creativity: A report by HMIE. Retrieved from http://dera.ioe.ac.uk/6273/1/Emerging%20Good%20practice%20in%20Promoting%20Creativity.pdf

Hetland, L., E. Winner, S. Veenema, and K. M. Sheridan. (2007). Studio thinking: The real benefits of visual arts education. NY, NY: Teachers College Press.

Hetland, L. and E. Winner. (2004). Cognitive transfer from arts education to non-arts outcomes: Research evidence and policy implications, in Handbook of research and policy in art education, edited by E.W. Eisner & M.D. Day. Mahway, NJ: Erlbaum.

Hirsch, M. (2010, August 12). We're number 11!. Newsweek. Retrieved from http://www.thedailybeast.com/newsweek/2010/08/12/how-to-understand-american-decline.html

The Lemelson-MIT Program. School of Engineering, Massachusetts Institute of Technology. (2003). Advancing inventive creativity through education. Boston, MA. Retrieved from http://web.mit.edu/invent/n-pressreleases/downloads/education.pdf

Lichtenberg, J., C. Woock, and M. Wright. (2008). Ready to innovate: Are educators and executives aligned on the creative readiness of the US workforce. NY, NY: The Conference Board.

Massey, W. (2011, May). Processes of inquiry: art, science, and culture of innovation. Presented at the National Science Foundation-funded Art of Science Learning Conference, Chicago, Ill.

National Academies of Science, National Academy Of Engineering, Institute Of Medicine. (2010). Rising above the gathering storm, revisited: Rapidly approaching category 5. Members of the 2005 rising above the gathering storm committee. Washington, DC: National Academies Press.

National Education Association. (n.d.) Preparing 21st century students for a global society: An educator's guide to the 4c's. Retrieved from http://Www.Nea.Org/Assets/Docs/A-Guide-To-Four-Cs.Pdf

National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academies Press.

National Science Board. (2010). Preparing the next generation of stem innovators: Identifying and developing our nation's human capital. Arlington, VA: National Science Foundation.

The Partnership for 21st Century Skills (P21). (2012). Framework for 21st century learning. Retrieved from http://www.p21.org/overview/skills-framework

Pink, D. (2005). A whole new mind: Moving from the information age to the conceptual age. New York, NY: Penguin Group.

The President's Council of Advisors On Science And Technology. (2010). Prepare and inspire: K-12 science, technology, engineering, and math (STEM) education for America's future. Washington, DC.

Robinson, K. (2006). Out of our minds: Learning to be creative. Chichester, UK: Capstone Books.

Robinson, K. (2009). The element. NY, NY: Viking Penguin Group.

Runco, M.A. (2007). Creativity: Theories and themes: research, development, and practice. Burlington, MA: Elsevier.

Sawyer, R. K. (2012). Explaining creativity: The science of human innovation. NY, NY: Oxford University Press.

Starko, A. (2004). Creativity in the classroom: Schools of curious delight. Mahwah, NY: Erlbaum.

Wagner, T. (2012). Creating innovators: The making of young people who will change the world. NY, NY: Scribner.

Wesson, K. (2002). Memory and the brain: How teaching leads to learning. Retrieved from http://Www.Sciencemaster.Com/Wesson/Articles.Php

Wiggins, G. and J. McTighe. (2006). Understanding by design. 2nd ed. Upper Saddle River, NJ: Pearson

Zhao, Y. (2009). Catching up or leading the way: American education in the age of globalization. Alexandria, VA: ASCD.

How SEAD Network Can Advance Experimental Economics: A Case Study of Innovation and Entrepreneurship in Support of Rural Community and Economic Development

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BACKGROUND

Since 2004, Advent GX has been researching and developing approaches to spur economic growth and job creation in America's rural regions. Advent GX identified gaps, studied best practices and evaluated tools for their potential application to rural settings. By providing access to relevant tools and using approaches that foster innovation and spur entrepreneurship and small business enterprise, Advent GX seeks to remove barriers and set communities on a path to prosperity.

Relevance of tools is fundamental. Too often well-meaning rural leaders attempt to employ methods that have proven effective in urban settings. Vastly different local dynamics, engagement and funding levels mean many conventional tools are out of reach and inapplicable. By modifying proven systems to the rural situation, facilitating creative collaborations, and allowing both local vision and market dynamics to drive strategy formation and implementation, Advent GX is moving beyond traditional rural development strategies and realizing success in assisting rural communities to achieve sustainable growth.

Toward this end, in 2011 Advent GX established the Innovation Underground in Historic Downtown Bryan, TX. A privately owned business incubator, the Innovation Underground is a place for entrepreneurs to grow businesses. Advent GX deliberately located the incubator in the heart of downtown. The Innovation Underground leverages cultural and heritage assets – including coffee shops, galleries, churches, restaurants – that are a natural draw to the area. Well promoted and supported, these assets become an even greater draw and can form the foundation for a cultural hub which in turn attracts more traditional and tourism business to the area. The result is economic growth and enhanced quality of life.

APPROACH

Advent GX uses a multi-disciplinary approach to support the development of businesses through the Innovation Underground.

Community-Based Entrepreneurship

Location within the heart of the community is essential. So too is a deliberate focus on serving the needs of both entrepreneurs seeking to start a business and freelancers in search of a quiet place to work. Serving both populations creates an ecosystem whereby freelancers feed off start-

ups' need for affordable services. Start-ups have access to affordable services, low rent, shared meeting facilities and Advent GX's version of entrepreneurial support systems. Unlike traditional business incubators and small business innovation centers, Advent GX advocates for a more aggressive and experimental brand of start-up employing the following approaches.

Experimental Economics: Using experimental methods to evaluate theoretical predictions of economic behavior, Advent GX encourages entrepreneurs to give their ideas a chance. Rather than expend large amounts of money on complex business plans that are often irrelevant before they are complete, we encourage entrepreneurs to instead invest in prototype products with which they can test markets and product features.

Behavioral Economics: Understanding the effects of social, cognitive and emotional factors on the economic decisions of individuals and institutions is fundamental to business planning and modeling. Advent GX tools support rapid evaluation of market prices and returns, and serves to support wise allocation of resources through the business and product development process.

Financial Engineering & Business Analytics: This cross-disciplinary field relies on computational intelligence, mathematical finance, numerical methods and computer simulations to make trading, hedging and investment decisions, all the while managing risk. Advent GX provides this support to start-ups to inform both financial models and fundraising decisions.

To encourage sustainable businesses, Advent GX assesses opportunities based on three primary considerations:

- Economic considerations for financial viability
- Ecological considerations for environmental sustainability
- Social considerations for quality of life impacts

Support for Cultural and Heritage Tourism

Tourism development is often considered to offer the best potential for attracting outside investment and generating sales tax revenue in rural communities. Experiential tourism–including heritage, cultural, nature tourism, to name a few–does in fact present a significant opportunity for rural places to expand the economic base and enhance quality of life. But tourism is just a beginning.

The natural attractants that bring visitors to local downtowns also serve to improve the quality of life. Establishing unique shopping experiences, live music venues, quality dining and the arts in a defined downtown district provides a venue for intellectual cultural engagement. The small setting and relatively low population creates a sense of community. Soon the creative class of artists and performers are mingling with engineers, lawyers and other professionals seeking respite after a long day of work.

This experiential lifestyle—typically only available in urban settings—is a key attractant for innovators and entrepreneurs seeking the rural quality of life. The Innovation Underground leverages the natural tourism attractants and provides a catalyst for entrepreneurial initiatives.

OUTCOMES

Advent GX set out to achieve break-even financial status of the Innovation Underground within its first year of operations. Though still in the development phases, the physical incubation offices at the Innovation Underground are fully occupied and Advent GX achieved break-even operations by month six. In addition to supporting a wide range of start-up activities, the Innovation Underground is home to a number of independent freelance professionals who work in the Creative Space, a co-working space for creative professionals. Start-up members of the Innovation Underground include:

- Rock the Republic
- Kootzin Apps
- Imani-Tumani-Upendo
- Blazing Forge Games
- Beautiful Abilities
- SEAD Gallery
- Texas A&M Statistical Services
- Maroon Weekly
- Hog Abatement Management Systems
- Grand Stafford Theater
- TripleStat
- Sideshow Creative

In addition to start-up activities, Advent GX is facilitating the development of community development projects that will add to the financial sustainability of the Innovation Underground and, once established, serve as ready models for replication in other communities. These initiatives include:

- DUFi (Distributed Urban Farming Initiative)
- SEAD Gallery (exploring collaborations in Science, Engineering, Art and Design)
- SEAD Academy (a conceptual education initiative focused on K-12)

LESSONS LEARNED

Through the first year of operations and several years of research prior to the opening of the incubator, Advent GX documented best practices and lessons learned. These findings inform suggested actions for further action that will follow in the next section.

Location Matters. The old adage – location, location, location – is true and perhaps even more so for communities seeking to spur entrepreneurial activity. Innovators want to be where the

action is. Most communities place business incubators in the cheapest possible real estate or in the middle of the fledgling business park where opportunities for inspiration and collaboration are, with only a few exceptions, scarce.

Follow the Passionate and Purpose Driven. Ignore the rest. Every successful initiative, be it a business, a charity event or the next disruptive technology, is championed by an individual willing to give life and limb for his or her great idea. Agility and an opportunistic mindset enable companies to follow the passionate to success, whether inside their own company or in the greater community.

Establish a compelling mission. The Innovation Underground supports start-up companies but the mission is community and economic development through heritage preservation. By choosing a 100-year-old building as its home, the Innovation Underground is supporting heritage preservation. This is compelling to local community thus fostering local engagement and adds to the sustainability of the project as a whole.

Engage, challenge and empower youth. Advent GX was able to accomplish a great deal in a short period of time and with a limited investment in large part because Advent GX makes interns a central part of company operations. By reaching out to student organizations and hiring both college and high school aged self-learners, Advent GX acquires affordable talent, gains insight into current and future trends and contributes to the development of a well-skilled workforce.

Reach out to and engage university leaders. Advent GX places high priority on providing support to the academic community. By reaching out to university leaders, supporting academic programs as lecturers, offering private sector perspectives and seeking opportunities for collaboration, Advent GX created a bridge between the campus and local communities. Resources and expertise are shared and innovation results.

Offer unique and meaningful programming. Advent GX launched the first in what will become a series of intimate lectures and recitals at the Innovation Underground with the goal of compelling intellectually motivated innovators to come together socially. Bringing together entrepreneurs, academics and community leaders sparks new ideas that become the catalysts for innovation. Local economic development is the result.

Provide access to technical resources and expertise. Entrepreneurs seeking to generate new business models and capitalize on emerging technologies need access to technical resources. The opportunity to learn the latest tools and experiment with new products is key to market penetration.

Embrace partnerships and collaboration. Leveraging resources, expertise and networks is central to the success of the Innovation Underground. Partnerships with academia, industry, government and non-profits must be formed with attention to the value each party will gain. SEAD Gallery, for example, provides a presence in downtown Bryan for the local arts council, gives a physical presence to and demonstrates the potential of the Network for Science,

Engineering, Art and Design and provides an enhanced experienced and source of revenue to contribute to economic viability of the Innovation Underground.

Private sector operations. Advent GX is a private company operating a business incubator. As in any private business, decisions are based on survival and long-term sustainability. By privatizing incubation, the Advent GX approach eliminates decision making based on political whim and provides start-ups the freedom to take risks and learn from failures without the threat of those failures being politicized. Additionally, the company's flat organization, focus on providing support as needed (avoiding one-size-fits-all services), and leaderships' inherent understanding of the entrepreneurial condition makes the operation viable from a practical perspective.

SUGGESTED ACTIONS

Suggested Action #1: Employ independent private sector company to direct and manage business incubation efforts.

Stakeholder(s): Local Governments, Economic Development Organizations, Economic Development Administration

Obstacle/Opportunity Addressed: Maximize entrepreneurship at the local level. Avoid injecting politics into start-up landscape.

Suggested Action #2: Fund faculty in residence to work alongside entrepreneurs in rural business incubators like the Innovation Underground.

Stakeholder: National Science Foundation, Economic Development Administration, Academia, Economic Development Organizations

Obstacle/Opportunity Addressed: Overcome barriers to meaningful academic engagement in the local community. Take advantage of opportunities for applied research; foster interdisciplinary collaboration.

Suggested Action #3: Fund the expansion of the Innovation Underground model to rural communities, creating a growing network of small businesses supporting rural innovation and economic vitality.

Stakeholder: Kauffman Foundation, Economic Development Administration

Obstacle/Opportunity Addressed: Overcome financial barriers to establishing Innovation Underground locations in rural communities that are most in need of entrepreneurial support and yet lacking resources to seed initiatives. Employ proven systems in use by Advent GX and build a supportive network of start-ups, all benefiting from private sector expertise.

Suggested Action #4: Establish Collaboration Lab at the Innovation Underground showcasing the latest technology tools and making them available for innovators seeking to build new skill sets and engage technology in the marketplace.

Stakeholders: Private industry; manufacturers of disruptive technologies, new software, developer kits, etc.

Obstacle/Opportunity Addressed: Overcome financial barriers that limit start-ups' access to new technology; provide a showcase opportunity for manufacturers who will also gain advocates/sales people in the process. Membership in the Innovation Underground network takes on a new level of value.

Suggested Action #5: Establish an exchange program to bring urban artists and entrepreneurs to rural communities and facilitate international cultural exchange.

Stakeholders: National Endowment for the Arts, Economic Development Administration, Department of State

Obstacle/Opportunity Addressed: Cultural exchange has long been recognized as an effective means to foster understanding and promote economic activity. By bringing international and urban artists and entrepreneurs to rural communities, the rural community will gain access to expertise and cultural resources that are otherwise out of reach. The exchange will develop networks for symposiums and events in unique locations, such as historic venues, creating intellectually engaging experiences and resulting in economic vitality.

Suggested Action #6: Establish an apprenticeship program at the Innovation Underground that funds high school student workers who provide technical design and development support to start-up companies under the direction of a qualified professional.

Stakeholders: Department of Labor, National Science Foundation, Private Industry

Obstacle/Opportunity Addressed: High school vocational programs are often effective but lack the resources to provide students with access to the latest technology tools; likewise, project work is approached as homework and thus lacks the intensity and rigor of real work products. Still, many high school students have both the aptitude and the interest in working with technology tools. In rural communities in particular, there is a lack of qualified technical workforce. An apprenticeship program at the Innovation Underground will contribute the development of well trained workforce while creating advocates for technology among students. Furthermore, student labor will provide affordable services to Innovation Underground start-up companies.

The Importance of Early and Persistent Arts and Crafts Education for Future Scientists and Engineers

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Like Leonardo da Vinci and Galileo Galilei, modern-day innovators in science and engineering are usually artists and craftsmen as well. There are practical reasons that this is so, for theirs is the task of converting ethereal ideas and provisional theories into the material objects and machines that do work in the real world. Understanding the many ways in which arts and crafts make possible innovation in sciences and engineering will enable society to develop the full potential of students in those fields.

Arts and crafts teach skills of relevance to STEM education outcomes:

K-12 curricula in most school systems focus on mathematical and verbal skills, but the ability to succeed in science and engineering requires a broader range of skills that can be, and often are, taught through arts and crafts. Arts- and crafts-trainable skills that have proven to enhance science, technology, engineering and mathematics (STEM) success in K-12 classrooms include the following "thinking tools":

1) observing (Checkovich & Sterling, 2001; Stein, et al., 2001);

2) imaging and visualization (Ferguson, 1977; Ferguson, 1992; Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999; Root-Bernstein & Root-Bernstein, 2005; Root-Bernstein, et al. 2008);

3) abstracting (Root-Bernstein, 1991; Bennedsen & Caspersen, 2008);

4) pattern recognition and pattern invention (Silvia, 1977; Burton, 1982; Hopkins, 1984; Pasnak, et al., 1987; Root-Bernstein & Root-Bernstein, 1999; Harvard, 2008);

5) analogizing (Glynn, 1991; Treagust, et al., 1992; Harrison & Treagust, 1993, 1994; Thiele & Treagust, 1994; Root-Bernstein & Root-Bernstein, 1999; Coll, et al., 2005);

6) dimensional thinking (Root-Bernstein & Root-Bernstein, 1999; Dodick & Orion, 2003; Steiff, et al., 2005; Kastens & Ishikawa, 2006);

7) modeling (Welden, 1999; Root-Bernstein & Root-Bernstein, 1999; Gilbert, et al., 2000; Ewing, et al., 2003; Steiff, Bateman &Uttal, 2005; Musante, 2006; Starfield & Salter, 2010);

8) body or kinesthetic thinking (Druyan, 1997; Root-Bernstein & Root-Bernstein, 1999; Root-Bernstein & Root-Bernstein, 2005; Robson, 2011);

9) manual dexterity (Wilson, 1982; Root-Bernstein, 1989);

10) familiarity with tools (Taylor, 1963; Root-Bernstein, et al., 1995; Root-Bernstein, et al., 2013);

11) transforming data into visual or graphical forms (Wilson, 1972; Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999);

12) converting theories into mechanical procedures (Wilson, 1972; Root-Bernstein, 1989; Root-Bernstein & Root-Bernstein, 1999);

14) and understanding data and experiments kinesthetically and empathetically (Root-Bernstein & Root-Bernstein, 1999; Dow, et al., 2007; Riess, et al., 2012; Chan, et al., 2012).

STEM professionals utilize the full range of these skills but textbooks fall short:

Our (unpublished) data on 235 mid-career scientists and engineers reveal widespread use of all the thinking tools listed above. They utilize imaging and visualization as often as logic, and rely on modeling, patterning, observing or analogizing as well as abstracting, playing, empathizing, kinesthetic thinking, manipulative skills, and other explicitly "artistic" and "craftsman-like" forms of thinking.

Despite actual science practice, we have additional unpublished data showing that science textbooks above the 8th grade level tend to teach only four of the above thinking skills besides logic: observing, analogizing, modeling, and patterning. Imaging and visualizing, abstracting, dimensional thinking, kinesthetic and empathetic thinking, as well as the ability to transform data or convert ideas into material procedures, go virtually untrained in science class.

STEM professionals acknowledge the arts and crafts for critical skill development:

In ongoing studies we have found that many scientists and engineers are explicitly aware that they developed critical skills through their arts and crafts training (LaMore, et al., 2012; Root-Bernstein, et al., 2013). More than 80% of these scientists and engineers affirm, in fact, that arts and crafts education should be required as part of STEM education (LaMore, et al., 2012; Root-Bernstein, et al., 2013).

Indeed, the full range of thinking tools are best learned through arts and crafts experiences, whether these experiences are integrated into science instruction or not. Furthermore, there are specific associations between skill and art form, e.g., abstracting with abstract visual art; empathizing and playacting with theater arts; modeling with crafts and sculpture; crafts with manipulative skills, etc. (Root-Bernstein & Root-Bernstein, 1999). Given the importance of abstracting, empathizing, modeling and more to STEM professionals, arts and crafts can provide

STEM students valuable training in the skills, knowledge and methods they will require to succeed.

Arts and crafts experience is highly correlated with STEM Success:

In our ongoing studies of scientists and engineers we have found that significant arts and crafts experience is highly correlated with professional success in science and engineering as measured by outcomes such as major prizes and honors, patents, or the founding of new high tech companies (Root-Bernstein, et al., 1995; Root-Bernstein & Root-Bernstein, 2004; Root-Bernstein, et al., 2008; Lamore, et al., 2012; Root-Bernstein, et al., 2013).

One of the most notable results of our research is that no particular art or craft confers advantage over any other: dance, music, drama, painting, sculpting, printmaking, photography, making and composing music, metal- and woodwork are all correlated with increased probability of success. The operant factor is not the type of art or craft, but the early introduction to arts and crafts in elementary and middle school years followed by persistent practice of that art or craft into adulthood.

We have also found that while exposure to arts and crafts can occur in a school setting, formal education is not a requirement for the observed correlation to success: arts and crafts classes in school are often supplemented or replaced by private lessons, informal mentoring at home or in community centers, or even by self-teaching. Again, the key element is not how an art or craft is learned, but how long it is pursued. Skill and knowledge transfer to science and technology arenas is, in short, most likely to occur as a result of arts and crafts mastery.

Current arts exposure K-16 is inadequate to STEM needs:

Given that most states within the U.S. and most countries around the world marginalize arts and crafts education, providing students with no more than an hour of such education per week and with no more than one or two arts or crafts throughout their entire schooling, our findings have clear policy implications for a wide range of parties (LaMore, et al., 2012; Root-Bernstein, et al., 2013). Students interested in pursuing a science or engineering career must recognized that their formal K-12 schooling is unlikely to prepare them adequately in the range of skills they will need to reach the top of their field.

STEM students, their parents, and those providing STEM education opportunities need to understand the inadequacies of standard STEM education. Arts and crafts are necessary supplements to the standard K-12 STEM curriculum. Educators and those setting educational policy must recognize that there is a robust literature linking success in science and engineering to skills such as observing, imaging and visualizing, abstracting, analogizing, empathizing, and modeling that are developed by arts and crafts training (reviewed above). Arts and crafts are not, therefore dispensable frills that can be eliminated from curricula whenever budgets need to be cut, but essential elements of science and engineering education.

Finally, legislators need to understand the practical value that lies in the skills taught through arts and crafts so that they are willing to provide robust funding not only for formal K-12 arts and

crafts curricula, but also for community centers, after-school programs associated with arts and crafts centers, museum- and concert hall-based educational programs, and other forms of informal arts and crafts education.

We therefore make the following suggested actions:

1) All stakeholders, including legislators, school boards, educators, parents and students, should be informed of the value of arts/crafts to STEM education.

   The scientific and technological value of arts and crafts education must be made evident through educational initiatives directed at the voting public, legislatures, school boards, educators, schools of education, parents and students. Each of these stakeholders requires a different type of information delivered in an appropriate medium and formulation (PBS special; editorials; white papers; curriculum revisions; etc.)

2) An organization should be established to lobby for arts/crafts in STEM education.

   An organization that can act as a lobbyist for the scientific and technological value of arts and crafts can educate and influence legislators, school boards, etc. This organization must produce clear position statements embodied in appropriate educational literature and supported by adequate research.

The following specific points must be made in order to influence stakeholders and harness the innovative potential of arts and crafts for transforming science and technology:

3) Arts and crafts education must begin early and progress well beyond introductory levels if it is to promote STEM learning.

   The best correlate we have of positive impact on science and engineering innovation in later life is an early introduction to arts and crafts. Those people who do not receive early and intensive arts and crafts education are very unlikely to take up an art or craft later in life (LaMore, et al, 2012; Root-Bernstein, et al., 2013). Moreover, those people who transfer their arts and crafts skills to science and engineering problem-solving are not those with a smattering of instruction, but those who have advanced in an art or craft over many years.

4) Arts and crafts education must be continuous and sustained from childhood through maturity if it is to have an impact STEM achievement.

   Our data show that individuals with sustained participation in arts and crafts with some degree of mastery are much more likely to become innovative scientists and engineers than those who participate in an art or craft for only a few years, presumably at introductory levels (LaMore, et al., 2012; Root-Bernstein, et al., 2013).

5) Arts and crafts education must be widely available and easily accessible across the socio-economic board if it is to open STEM training and practice to historically disadvantaged groups such as women and minorities (Lownds, et al., 2010).

Our data (Root-Bernstein, et al., 2013) and that of Catterall (2010) suggest that arts-and-crafts training levels the playing field for individuals from low socio-economic backgrounds, making them much more likely to succeed in science and engineering professions and to return the investment society makes in them by inventing patents and founding new companies.

6) Arts and crafts education designed to promote STEM education must be supported not only in schools but also through community programs, formal and informal mentoring, arts-related business initiatives and the out-reach programs of museums, symphonies and other public arts institutions.

Our data show that arts and crafts education occurs as frequently outside of school systems as in them and therefore must be viewed as a synergistic system. Such a system of mutually supportive organizations can provide exposure to a variety of arts in a variety of venues as well as access to training, materials, exhibition and performance spaces at near-professional levels for those sustaining avocational arts interests and practice (Root-Bernstein, et al., 2013). Everyone from business people to arts and crafts entrepreneurs and independent music and performance teachers have a stake in this system.

7) Arts and crafts must be placed on a par with language skills, mathematics and sciences in school and university curricula because the arts train equally important skills and convey equally important knowledge (Root-Bernstein & Root-Bernstein, 1999 and references provided above).

Everyone desiring to improve our student's capacity for creativity and innovation is a stakeholder in this change.

8) Arts and crafts teachers must be granted the same status as language, mathematics and science teachers, and equivalent amounts of time in the school day to work with their students (Root-Bernstein & Root-Bernstein, 1999).

Teachers are the main stakeholders in this suggested action. Without this change in the system, the changes in the curriculum necessary to promote arts-assisted STEM innovations cannot be implemented.

In order to achieve the last six goals listed above, arts and crafts education should emphasize elements of creative education often ignored by other disciplines (Root-Bernstein & Root-Bernstein, 1999) including, but not limited to the following:

9) Arts and crafts education should emphasize the universal processes of invention in addition to the acquisition of specific disciplinary knowledge (Root-Bernstein & Root-Bernstein, 1999).

Creative thinking partakes of both domain general and domain specific processes involving, respectively, generative and compositional stages of thought and action (Sternberg, et al., 2004).

10) Arts and crafts education should emphasize the intuitive and imaginative skills necessary to foster invention.

The current education system tends to confuse the means by which we communicate (languages, mathematics, pictures, sounds, movements) with the ways in which we think and create. Creative thinking actually begins for people in all disciplines with pre-verbal sensations, emotions, visions, body feelings and tensions that are explored and exploited by artists and craftspeople of all sorts (Root-Bernstein & Root-Bernstein, 1999). We must teach our students how to use these emotions, feelings and sensations if we wish to nurture their creative capacities.

11) Arts and crafts education should be integrated into the general curriculum by using a common descriptive language for creative and innovative processes.

The 13 "tools for thinking" as described by Root-Bernstein & Root-Bernstein (1999) provide a basic vocabulary that can be used by students, teachers and parents in an integrated and mutually reinforcing manner.

12) Arts and crafts education, while developing necessary disciplinary skills and knowledge, should emphasize the trans-disciplinary nature of those skills and knowledge in order to promote skill and knowledge transfer to science and engineering practices (Root-Bernstein & Root-Bernstein, 1999).

It is a well-established pedagogical principle that knowledge transfer is promoted by teaching students that their knowledge CAN be transferred. Observing, for instance, can be taught in an art or dance class and explicitly transferred for use in a biology class. Patterning can be developed in a painting or music class and applied in a math class. In this way arts and crafts education can be integrated into existing educational curricula, improving them and making them more efficient (Root-Bernstein & Root-Bernstein, 1999).

13) Arts and crafts education should focus on the experiences of individuals and institutions notably bridging disciplines as exemplars of the trans-disciplinary nature of innovation (Root-Bernstein & Root-Bernstein, 1999).

Providing explicit examples of how polymathic individuals such as Leonardo da Vinci have managed skill and knowledge transfer is likely to be particularly effective.

Finally, new forms of research need to be funded and undertaken in order to provide the data-driven arguments necessary to convince legislators, school boards, educators and parents that arts education will boost STEM skills and knowledge:

14) Further research is necessary to establish that the hands-on practice of arts and crafts improves STEM education outcomes such as improved standardized test scores, graduation rates, enrollment in STEM majors in college, etc.

   The National Science Foundation and the National Endowment for the Arts, as well as private philanthropic foundations, should be encouraged to fund such research.

15) Further research is necessary to establish that the value of arts and crafts for STEM education resides in the development and exercise of tools for thinking that encompass observing, imaging, abstracting, patterning, analogizing, empathizing, modeling, playing, dimensional thinking, etc. (Root-Bernstein & Root-Bernstein, 1999).

   While some studies exist in some STEM subjects for select age groups for each of these thinking tools, the generality of the findings has not been established across all STEM subjects or age groups, nor has the impact of training in more than one thinking tool at a time been investigated. Once again, the National Science Foundation and the National Endowment for the Arts, as well as private philanthropic foundations, should be encouraged to fund such research.

16) Finally, there appears to be no information about the arts and crafts experiences of legislators, school board members, or education faculty, yet this information is necessary if we are to address effectively the prejudices these groups currently have against arts and crafts in education.

   The National Endowment for the Arts and private foundations supporting arts education should be encouraged to establish research programs in this area. Informed outreach to these groups in ways that address their particular concerns may prove critical to the effective promotion of arts and crafts education, not only for the sake of the arts, but for the sake of science, technology, engineering and math—and the future of our society.

REFERENCES

Alias M, Black TR, Grey DE. (2002). Effect of instructions on spatial visualization ability in civil engineering students. International Education Journal, 3 (1),1-12.
Bennedsen J & Caspersen, ME. (2008). Abstraction ability as an indicator of success for learning computing science? ICER '08 Proceeding of the Fourth international Workshop on Computing Education Research, 15-26. New York, NY, ACM. Retrieved November 2012 from http://dl.acm.org/citation.cfm?doid=1404520.1404523
Burton, GM. (1982). Patterning: Powerful play. School Science and Mathematics, 82, 39-44.
Catterall J. (2009). Doing Well and Doing Good by Doing Art: The Effects of Education in the Visual and Performing Arts on the Achievements and Values of Young Adults. Los Angeles/London: Imagination Group/I-Book Group

Chan, AAY-H. (2012). Anthropomorphism as a conservation tool. Biodiversity and Conservation, 21 (7), 1889-1892.

Checkovich BH & Sterling DR. (2001). Oh say can you see? Science & Children, 38 (4), 32-35.

Coll RK, France B, Taylor I. (2005). The role of models and analogies in science education: implications from research. International Journal of Science Education, 27 (2), 183-198.

Deno JA. (1995). The relationship of previous experiences to spatial visualisation ability. Engineering Design Graphics Journal, Autumn, 5-17.

Dodick J & Orion N. (2003).Cognitive factors affecting student understanding of geologic time. Journal of Research in Science Teaching, 40 (4), 415-442.

Dow AW, Leong D, Anderson A & Wenzel RP (VCU Theater-Medicine Team). (2007). Using theater to teach clinical empathy: a pilot study. J Gen Intern Med., 22 (8), 1114-8.

Druyan, S. (1997). Effect of the kinesthetic conflict on promoting scientific reasoning. Journal of Research in Science Teaching, 34 (10), 1083-1099.

Ewing H, Hogan K, Keesing F, Bugmann H, Berkowitz AR, Gross L, Oris J & Wright J. (2003). The role of modeling in undergraduate education. In CD Canham, JJ Cole & WK Laurenroth (Eds.), Models in Ecosystem Science (pp. 413–427). Princeton, NJ: Princeton University Press.

Ferguson ES. (1977). The mind's eye: Nonverbal thought in technology. Science, 197, 827-836.

Ferguson ES. (1992). Engineering and the Mind's Eye. Cambridge, Mass.: MIT Press.

Gilbert JK, Boulter CJ, & Elmer R. (2000). Positioning models in science education and in design and technology education. In JK Gilbert & CJ Boulter (Eds.), Developing Models in Science Education (pp. 3-17). Netherlands: Kluwer Academic Publishers.

Glynn SM. (1991). Explaining science concepts: A Teaching-with-analogies model. In SM Glynn, RH Yeany & BK Britton (Eds.), The Psychology of Learning Science (pp. 219-240). Hillsdale, NJ: Erlbaum.

Harrison AG & Treagust DF. (1993). Teaching with analogies: A case study in grade-10 optics. Journal of Research in Science Teaching, 30, 1291-1307.

Harrison AG & Treagust DF. (1994). Science analogies. The Science Teacher, 61, 40-43.

Harvard Graduate School of Education. 2008. Causal patterns in science, a professional development resource. Retrieved November 14, 2012 from http://www.cfa.harvard.edu/smg/Website/UCP/

Hindle B. (1981). Emulation and Invention. New York: New York University Press.

Hopkins RL. (1984). Educating the right brain: Why we need to teach patterning. Clearing House, 58, 132-134.

Kastens KA & Ishikawa T. (2006). Spatial thinking in the geosciences and cognitive sciences: A cross-disciplinary look at the intersection of the two fields. In S Mazzoli & RWH Butler (Eds.), Earth And Mind: How Geologists Think And Learn About The Earth, Book Series: Geological Society of America Special Papers, 413, 53-76.

LaMore R, Root-Bernstein RS, Lawton J, Schweitzer J, Root-Bernstein M, Roraback E, Peruski A, Van Dyke M, Fernandez L. (2012). Arts and crafts: Critical to economic innovation. Economic Development Quarterly, December.

Lownds N, Poff K, Root-Bernstein M, Root-Bernstein RS .(2010).Thinking tools, science curricula, and cultural learning: Does the disconnect promote poor performance by minorities in STEM subjects? SACNAS News, 1 (2), 8-9.

Musante S. (2006). Strategies for teaching modeling to students. American Institute of Biological Sciences. Retrieved November 14, 20120 from www.aibs.org/eye-on-education/eye_on_education_2006_04.html

Pasnak R, Brown K, Kurkjian M, Mattran K, Triana E & Yamamota N. (1987). Cognitive gains through training on classification, seriation, and conservation. Genetic, General, and Social Psychology Monographs, 113, 293-321.

Riess H, Kelley JM, Bailey RW, Dunn EJ, Phillips M. (2012). Empathy training for resident physicians: A Randomized controlled trial of a neuroscience-informed curriculum. Journal of General Internal Medicine 27(10):1280-6.

Robson D. (2011). Your clever body: Thinking from head to toe. New Scientist, 2834, 21 October. Also retrieved November 2012 from http://www.newscientist.com/article/mg21228341.500-your-clever-body-thinking-from-head-to-toe.html

Root-Bernstein M & Root-Bernstein RS. (2005). Body thinking beyond dance: A Tools for thinking approach. In L Overby & B Lepczyk, (Eds.), Dance: Current Selected Research, 5, 173-202.

Root-Bernstein RS. (1991). Teaching abstracting in an integrated art and science curriculum. RoeperReview, 13 (2), 85-90.

Root-Bernstein RS. (1989). Discovering, Inventing and Solving Problems at the Frontiers of Scientific Knowledge. Cambridge, MA: Harvard University Press.

Root-Bernstein RS, Allen L, Beach L, Bhadula R, Fast J, Hosey C, Kremkow B, Lapp J, Lonc K, Pawelec K, Podufaly A, Russ C, Tennant L, Vrtis E & Weinlander S. (2008). Arts foster success: Comparison of Nobel prizewinners, Royal Society, National Academy, and Sigma Xi members. J Psychol Sci Tech, 1 (2), 51-63.

Root-Bernstein RS, Bernstein M & Garnier HW. Correlations between avocations, scientific style, and professional impact of thirty-eight scientists of the Eiduson study. Creativity Research Journal, 8, 115-137.

Root-Bernstein RS, LaMore R, Lawton J, Schweitzer J, Root-Bernstein M, Roraback E, Peruski A, Van Dyke M. (2013, in press). Arts, crafts and STEM Innovation: A Network approach to understanding the creative knowledge economy. In M Rush (Ed.), The Arts, New Growth, and Economic Development. Washington DC: National Endowment for the Arts & The Brookings Institution.

Root-Bernstein RS & Root-Bernstein M. (1999). Sparks of Genius. The Thirteen Thinking Tools of the World's Most Creative People. Boston: Houghton Mifflin.

Root-Bernstein RS & Root-Bernstein M. (2004). Artistic scientists and scientific artists: The Link between polymathy and creativity. In R Sternberg, EL Grigorenko, & JL Singer (Eds.), Creativity: From Potential to Realization (pp. 127-151). Washington, DC: American Psychological Association.

Silvia EM. (1977). Patterning: An Aid to teaching math skills. School Science and Mathematics, 77 (7), 567-577.

Sorby SA & Baartmans BG. (1996). A course for the development of 3D spatial visualization skills. Engineering Design Graphics Journal, 60 (1), 13-20,

Sorby S. (2009). Developing spatial cognitive skills among middle school students. Cognitive Processes, 10, Suppl 2: S312–S315. DOI 10.1007/s10339-009-0310-y

Starfield AM & Salter RM. (2010). Thoughts on a general undergraduate modeling course and software to support it. Transactions of the Royal Society of South Africa, 65 (2), 116–121.

Sternberg R, Grigorenko EL & Singer, JL (Eds.) (2004).Creativity: From Potential to Realization. Washington, DC: American Psychological Association.

Stein M, McNair S & Butcher J. (2001). Drawing on student understanding. Science & Children, 38 (4), 18-22.

Stieff M. (2011). When is a molecule three dimensional? A Task-specific role for imagistic reasoning in advanced chemistry. Science Education, 95 (2), 310-336.

Stieff M, Bateman RC, Jr & Uttal DH. (2005). Teaching and learning with three-dimensional representations. In JK Gilbert (Ed.), Visualization in Science Education,Book Series: Models and Modeling in Science Education, 1, 93-+

Taylor DW. (1963). Variables related to creativity and productivity among men in two research laboratories. In CW Taylor & F Barron (Eds.), Scientific creativity: Its recognition and development (pp. 228-250). New York: Wiley.

Thiele RB & Treagust DF. (1994). An interpretive examination of high school chemistry teachers' analogical explanations. Journal of Research in Science Teaching, 31, 227-242.

Treagust DF, Duit R, Joslin P & Lindauer I. (1992). Science teachers' use of analogies: Observations from classroom practice. International Journal of Science Education, 14, 413-422.

Wilson M. (1972). Passion to Know. Garden City, NY: Doubleday.

Welden CW. (1999). Using spreadsheets to teach ecological modeling. Ecological Society of America Bulletin, 80 (1), 64–67. Retrieved November 2012 from http://www.esajournals.org/doi/pdf/10.1890/0012-9623%281999%29080%5B0064%3ATT%5D2.0.CO%3B2

Case Study: Cultivating Art and Science in the Petri Dish:
The Culture at Work Project

Coordinator: Sherryl Ryan

SUGGESTED ACTIONS

Action 1: Acknowledge and value the integrity of artist knowledge, creativity and embodied cognition in collaborative art science opportunities.

Problem: The value of the scientist and the scientific problem under investigation in collaborative research opportunities is weighted in favour of the 'preciousness' of the scientist or science researcher's time, financial and professional value above that of the artist, which can and does compromise true collaborative research. Potential significant value paradigm shifts need to take place across the education spectrum for art science innovation to flourish.

Stakeholders: Artists, Scientists, Universities and Science Institutions, Art Science Institutions.

Recommended solution: To acknowledge and value the artist and scientist as equal contributors in collaborative projects within a framework of financial, intellectual and creative equality.

Suggested Actions: New Art Science Collaborative contracts to be designed for art science collaborations that adhere to principles of equality for artists and scientists for financial, intellectual and creative contribution. A new paradigm shift on the value of the artist and scientist collaboration be introduced to the education system. New tools should be designed for measuring collaborative and potential value in relation to creativity and intellectual contribution of both artist and scientist. Published work should acknowledge the contribution of the artist and scientists intellectual and creative contribution and the significance of the joint collaborative value.

Action 2: Recognition of the value of the experimental research process of artists working with science content and science collaborations and recognition of the longer working time frame that is required to build partnerships, collaborations and projects from 1-5 years. Financial support for the speculative time frame, collaborative time frame and output time frame and associated costs incurred by arts organisations engaging in art science collaborative projects needs to be acknowledged and. addressed.

Problem: Collaborative art science partnerships and projects require a range of timeframes for quality outcomes and the financial support required is not currently readily available to support the operational costs associated with projects. Annual grants advertised in national and state bodies funding rounds work on 6 month/12 month application and announcement cycles and require future planning that is not conducive to longer research process. Three year ARC research grants are better suited to art science collaborations however these are aligned to universities and are not readily accessible to arts art-science organisations.

Stakeholders: National Government arts funding agencies, State Government arts funding agencies, City Councils, Philanthropists, Universities, Science Institutions, Art Science Institutions, Artists, Scientists.

Recommended solution: Government National and State agencies and Philathropists to identify and acknowledge the value of art science innovation in the future world problems. Prioritise long term funding specifically for art science collaborations acknowledging the need for experimental and developmental timeframes for true innovative collaboration and partnership building. Acknowledgement of the value of art science models developed through 3-5 year projects as catalysts and currency for art science education frameworks and art science curriculum development across the spectrum of education from elementary school to college. The value of the artist in society would increase through these initiatives and create role models for future Creative Industry and Innovation in the next quarter century.

Suggested Actions: National and State funding agencies set aside specific funding for long term art science collaborations for arts and art science organisations for the purpose of developing long term 2-5 years art science collaborations and projects with scientists and science organisations, universities. Funded art science models and partnership projects be linked across education from elementary schools to college and beyond with the purpose of introducing the artscience collaboration to the next generation of educators, students and policy makers.

Humanities Education in Karnataka

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Abstract: Everybody seems to recognize that there is a crisis in humanities education around the world. As part of a report which I wrote for the Karnataka Knowledge Commission, I looked at the state of humanities education in the state of Karnataka, which, incidentally, is known as the science and IT capital of India. These are students who primarily enroll for the BA program across the state. The data from Karnataka actually reflect a larger trend across India – that a large number of students in the undergraduate actually take BA and related 'arts' programs. The figures could be anywhere from 40 to 50% of the total enrolment of undergraduates. Thus, in India, the problem is not that students are not taking up liberal arts and humanities, but the quality of these programs which range from the abysmal to mediocre with few exceptions. This note discusses ways by which we could address this problem in the State of Karnataka but might have some lessons for some others too.

Objective, Scope and Principle of Teaching Humanities

In the context of the undergraduate Indian education system, the Arts degree (BA) encapsulates both the Humanities and the Social Sciences.

Training in Humanities leads towards understanding, as well as promoting, the civilizational aspects of a society. As many of the programmes in Humanities programs, these disciplines promote critical and creative thinking, not just within a discipline but also about the larger culture. In this sense, the Humanities are the foundation for all disciplines for understanding the human condition and are a prerequisite to understanding the nature of knowledge and how humans should act. Disciplines like literature and languages not only enrich a culture but they are also necessary for other disciplines such as the social and natural sciences. As much as mathematics is called the queen of the natural sciences so also can philosophy be called the queen of the social sciences and arts. Philosophy is also essential to understanding the nature of science and its impact on humans and society.

Today, almost all disciplines underscore the importance of multidisciplinarity. Even within disciplines such as physics and chemistry, the need for multidisciplinarity is obvious. Research in these fields has become very multidisciplinary. One of the fundamental models of multidisciplinarity comes from the Humanities. Whether it is philosophical traditions or study of art or culture studies, there is an inherent sense of multidisciplinarity present in these approaches.

Most important of all, training in Humanities develops responsible citizenship. If education is seen as a process which is more than transmitting information then it is imperative that a student learns not just what is taught as knowledge but the very nature of that knowledge. To be a responsible citizen is to know how to understand how knowledge has and can be used for the greater good of society. For example, knowing about nature by learning natural sciences is not

enough to teach one how to use this knowledge in a humane manner. It is training in the humanities which will alert the student to the various dimensions of this knowledge derived in the sciences. So also for other disciplines and activities.

Summary of Objectives of Humanities Education:

- To create a rounded student well-versed in critical thinking, communication skills both in speaking and writing, creative action and social responsibility.

- To inculcate the values of humanity, good and responsible citizenship, ethical action, equitable and just notions of social existence.

- To understand how different notions of knowledge and truth, rigour and merit are present in these disciplines.

- To help students understand the foundational basis of other human activities such as science and the arts.

- To create aesthetic appreciation of civilizational contributions from literature and the arts, including music.

Present Status of Humanities Education in Karnataka

There are a large number of students who are enrolled in BA. The popular subjects covered in BA include History, Economics, Sociology, English, Kannada, Hindi, Urdu, Social Work, Political Science, Library Science, Philosophy, Geography, Education, Home Science, Psychology, Archaeology, Musicology, Physical Education, Journalism and so on.

Significantly the BA has the highest number of colleges and students in the State. At the undergraduate level, statewide the highest enrollment is in BA. For example, for the year 2007-08, the enrolment figures were as follows: Out of a total of 2,01,459 students, 84,075 students were enrolled in the BA courses as compared to 34,933 in BSc, 64,119 in BCom and 18,332 in other courses. Also important is the gender breakup: out of 84,075 students in BA, 44,432 were male students and 39,643 were female. Males were less in BSc compared to females. Overall there were more male students – 1,04,900 to 96,559, but the difference is not much.

In terms of regions, except for Bangalore and Mangalore, the enrolment in BA was higher compared to the other streams. In the case of Bangalore, this disparity is primarily in Bangalore Urban where BCom enrolment exceeds BA and BSc enrolment, and is nearly double – 19,597 to 8,839 (BA) and 8,665 (BSc). However, in the rural and semiurban areas the BA enrolment was the highest except for Kolar where BCom was significantly higher.

Similarly in the Mysore region, it is only in Mysore city that the enrolment in BCom is greater than BA but elsewhere BA has the highest enrolment. In Mangalore region, the total number in BCom is greater than in BA and BSc. Both in the Dakshina Kannada and Udupi region falling

under this division, the BCom enrolment is more than BA (and BSc). In Dharwad division, all the regions have highest enrolment in BA; so also for the Gulbarga region.

So it seems that in more urbanized areas such as Bangalore, Mysore and Dakshina Kannada, there is more interest and availability of BCom courses. Even in these areas, BA comes after BCom and the science stream has the least enrolment among these three.
Again of some significance is the figure for government colleges. The BA enrolment in government degree colleges is far greater than BCom and BSc – 77,602 in BA as compared to 12,537 in BSc and 19,015 in BCom. So if we compare this with total enrolment in private and government colleges, we can see that private colleges enrolment should be as follows: 7,013 in BA, 22,396 in BSc and 45,104 in BCom. As seems obvious, the courses which are preferred in private colleges seem to be BCom and BSc. Therefore, the government colleges essentially carry the burden of teaching BA in the state.

Given the general problem of standards in government colleges, this has serious consequences for the state of undergraduate education in social sciences and humanities in Karnataka. Given that among all these streams, BA is the one which has the most number of mainstream disciplines – history, sociology, political science, economics, anthropology, psychology, journalism, home science, philosophy, literature and so on – it is all the more worrying that private colleges only show an enrolment of 7,013 students. This is about one-third of BSc students and one-seventh of BCom students. In terms of total enrolment in private colleges, BA enrolment is less than 10% whereas in government colleges it is nearly 60%

This also means that the number of faculty in arts is significantly more in Government colleges. For example, in Kuvempu University, the number of teachers in arts stream is 964 as compared to 161 for commerce.
Under Mysore University, out of a total of 224 colleges, 97 of them offer Arts degree. The number of teachers in Arts is 1,780 out of a total of 2,858 teachers (in Arts, Commerce, Management and Law). Nearly 28,000 students are enrolled in the Arts stream out of a total of nearly 50,000 students. (The number of girl students in arts is more than the male students: 14,721 to 13,475.)

In Karnatak University, the total number of students in arts is about 48,000 compared to a total of nearly 77,000 students in the combined disciplines. (Interestingly, the number of students enrolled in BA has steadily decreased from 2003 to 2008. The enrollment for the 2003-04 was 68,100 students and in 2007-08 it was 50,770 and there is a decline every year.)

Both in Gulbarga and Kuvempu Universities, the enrollment in BA is significantly higher than in other streams. In both these universities it is over 50% – again we can note that this is largely due to the semi-urban and rural enrollment in these areas. In Karnataka State Women's University, Bijapur, the Arts intake is 9,265 out of a total of 12,045 students enrolled in arts, commerce, management and law.

Students from liberal arts background and with access to good schools tend to take subjects in the art stream because of their interest in subjects like history and sociology. But the majority of the students take BA in rural areas and in government colleges. Very often, this is because they

are not interested in science or are not particularly inclined to mathematics. BA offers them options such as the Civil Services, teaching or a wide variety of jobs which only require a general graduate degree. Another important reason for so many students taking BA in rural areas is that these students study in Kannada or take Kannada as a major subject in their BA.

Even in the urban areas, students tend to take BA largely because of their disinterest in science subjects or in professional courses. However, there a good number of students who are drawn to BA, particularly in the field of literature.

The colleges are classified as government, private aided (private colleges aided by the government) and unaided colleges. But the distribution of these colleges is again skewed towards the urban sector. For example, in Bangalore Urban the ratio of government to private aided colleges is 19:44 and in other regions it is 50:17, a complete reversal. Given the state of government colleges, one can see the impact this has on overall education in the State. Interestingly, almost all other Universities such as Mangalore University, Karnataka University and even Gulbarga University do not show this disparity since there seem to be more equitable distribution of private and government colleges. This is so except for Bangalore and Mysore Universities. This is an interesting phenomenon worthy of more attention.

The total budget for all the 647 colleges in the state (including government and private aided colleges) for 2009-2010 is 51721.89 Lakhs. This is not a small amount but it should be seen in the context of the overall budget.

Similar Programmes Elsewhere

Around the world, Humanities and Liberal Arts have responded to changing times in many creative ways. They are able to attract some of the best students because of the way they position themselves. These disciplines are also respected in the larger society which makes it easier for students to join these courses. But almost all the good programmes in Humanities stress certain common advantages of getting an undergraduate degree in Humanities such as developing critical thinking, improving writing and communication skills, capacity for problem solving, learning to do research, bring together ideas from different disciplines and so on.

The stress on critical thinking and language skills, particularly writing skills, is common to many such programmes across the world. Among the core disciplines in Humanities are philosophy and literature. Arts – fine arts and performance arts – are also integral to many programmes. Also, in recent times, there have been many interdisciplinary combinations of themes which define the Humanities degree.

Typically, a BA degree has one major and one minor discipline. It also allows a selection from many languages. Many good programmes also allow for double degrees – majoring in more than one discipline. Typically, the subjects that are taught as part of the BA degree in many good programmes in the world are as follows:

Languages (this would include teaching different languages such as Japanese, Chinese, French etc., In the Indian context, this would include various Indian languages.)

Traditional disciplines such as Anthropology, Classics, Economics, History, Linguistics, Philosophy, Politics, Psychology.

Variety of *new disciplines* such as: International Studies, Asian and European Studies, Development Studies, Music Studies, Gender Studies, Environmental Studies.

New combinations of themes are also offered as subjects: Arts and Value, Biography/History, Film, Globalisation, Cultural Studies, Religion and Ethics.
As we can notice, such a wide variety of disciplines are not offered as part of BA in our colleges. Nor is it possible to choose subjects from these disciplines and mix courses from different disciplines. Also, courses in interdisciplinary topics such as "Gender and Work", "Art and Creativity", "Biography", "Film", "Globalization" and "Popular Culture" are not only topical but also of interest to students. Such courses are not a part of our BA programme.

Problems

As the numbers indicate, the number of students doing BA is very high. However, the problem seems to be that most of these students are in government colleges and in non-urban areas. For students who are not in the urban areas the problem of infrastructure is a serious one. This includes lack of access to books, journals and in general the absence of a decent library.

But the problem begins earlier. Students do not know what the BA degree is about. They are not sure of what they will be studying and learning, particularly because of the step-motherly treatment towards these disciplines at the school level. Given the emphasis on science, engineering and medicine it is not surprising that there is a lack of interest not only in teaching the subjects of humanities but also a lack of information about the higher degrees in humanities.

Even the parents are often clueless about what these courses are. So very often the BA degree becomes a default degree if the student does not get admission into any other course. Part of the disinterest lies in the lack of information on the career options that are available to the students after their BA degree. This cultural ignorance about the BA subjects has serious consequences since parents are not encouraged to send students to the BA courses even if their children are interested in these disciplines. This problem is compounded also because there is no strong tradition of arts disciplines in high schools.
Once students join BA, then they run into a different set of problems. First of all, the courses are very regimentalized. There is little creativity in the syllabus. And except for disciplines such as literature, students often have little understanding of why they are studying what they are asked to study. The diversity of disciplines is another problem since very often specialized teachers are needed for each of these disciplines.

On the ground, the situation is not that good. For example, while there is a recommended teacher to student ratio, it is often flouted in the case of BA courses. College teachers in Bangalore inform us that many times there are about 150 students in a class. This not only increases the load associated with teaching and the pedagogical style adopted (with lecture mode being the most expedient) it also creates new problems related to grading.

The market dictates the amenities for the teachers also! Well paying courses have better infrastructure for teachers. For example, we were told that for teachers in humanities there are no toilets and proper staff room since these courses do not generate income like some other courses do.

The payment to teachers is also a problem. If teachers are paid by the government then there does not seem to be much of a problem. But in many private colleges many teachers are underpaid and work on contract system and these lead to their own set of problems.

Associated with this is the more worrying problem of teacher training. Most often students who get a postgraduate degree directly come into teaching. There is no idea of teacher-training for these new recruits. Interestingly, the teachers themselves have repeatedly asked for some kind of teacher training before hiring somebody as a teacher.

Generally, it is widely accepted that one of the most serious problem afflicting the BA programme is student evaluation. Both in terms of quality and quantity, and also because of obsolete ways of testing students, there is a serious lacunae in evaluation.

It was also generally felt that the curriculum has become almost obsolete. It was felt that some soft-skills were a must for the BA students. Given the rigidity of the courses and syllabus, it is not a surprise that students often find these courses outdated and irrelevant. The flexibility which is a mark of an effective educational system is badly missing in the BA courses.

The Administration also contributes to this problem. Teachers have told us about the unnecessarily high staff to student ratio in colleges. Among other things, this also leads the administration to treat the students badly. This is a complaint that is almost universal in Indian colleges and universities.

While the lack of library is universal – both in urban and rural areas – the added problem in rural and semiurban areas is the lack of books in Kannada. For disciplines in social sciences and humanities where much of the literature is derived from the west and published in English, the lack of books in Kannada is a serious obstacle to effective teaching of these disciplines.

Finally, unlike the best programmes in the world in the humanities, our colleges and universities do not have a rich research culture. Most often, there is no research activity at all. As is well understood around the world, a good research culture also leads to a quality teaching culture.

One contributing factor to these problems is the lack of a public culture around these disciplines. There is very little in the news media about these courses, especially when contrasted with the large amount of material published on the science and professional courses. Often there are no public figures who speak on behalf of these disciplines unlike the community of scientists. Even social science students will find it easy to name the well known scientists in the country but find it problematical to name such figures in humanities and social sciences! This public nurturing of these disciplines is a must if students and parents should change their views.

The lack of proper national or state agencies to support and nurture these disciplines is another important problem. For example, the sciences have very well established agencies both at the state and national level which support teaching in various ways. The social sciences as well as humanities suffer seriously due to this lack.

There is also a fundamental problem of language. Since so much of BA is taught in the rural areas, the language of instruction often is Kannada. Proper textbooks and other resource material in the disciplines are not available as much in Kannada as in English. This means that students cannot access important texts in these disciplines.

The case of philosophy

Philosophy is the queen of disciplines. Just as mathematics is seen as the discipline most important to study science, philosophy is the discipline which is at the foundation of almost all the disciplines of social science. In fact, almost all these fields (including those in the natural sciences) not only have their origins in philosophy but are also strongly influenced by philosophical ideas.

There is little doubt among teachers and educationists about the importance of philosophy in the curriculum but ironically this recognition has not translated into action. In particular, Karnataka state has the dubious distinction of very few programmes in philosophy. Not only have new programmes not been started but even existing ones have been consistently closed down.

The general problems associated with arts teaching are present in the case of philosophy teaching in Karnataka. In fact, there are more problems. One has to do with the perception of philosophy: philosophy is often confused with religion and since religious studies are generally not seen to be part of secular education, philosophy is also ignored.

Secondly, colleges and universities close philosophy programmes because of lack of students. But this is a vicious circle: often there are very few students because there are very few teachers. The lack of students means that there are not enough postgraduate and doctoral students in philosophy. This means that there are lesser number of teachers who can teach philosophy. Many of the other problems mentioned above are applicable to philosophy also.

The Way Forward

Many of these problems afflicting the social science and humanities disciplines taught in BA can be rectified.

The problem about information about these courses can be addressed quite effectively. There is a great demand for disciplines like philosophy, literature, arts and history. But there is not enough of a public discourse on the importance of these disciplines. For example, philosophy is so integral to so many professional activities and yet it is not promoted as such. It is of great surprise that even prestigious law programmes in the country do not have a core course in philosophy or logic especially considering the close relation between philosophy and law. Similarly for various other professional and non-professional courses.

What is true for philosophy is also true for the social sciences. One cannot be a part of the Indian society as a scientist, engineer, doctor or administrator without having basic knowledge about Indian society. Social science disciplines inculcate this social awareness which is so essential for good citizenship. The very meaning of development is not one restricted to material development but to development of values also. These are part of a broader arts education. In fact, arts education must be made mandatory for all students, including science and engineering students.

To take care of the problem of lack of teachers, some new programmes can be initiated including some on teacher training in different disciplines.
It is extremely important to increase access to books and other library resources in these fields. Karnataka, particularly Bangalore, has world class libraries in the natural sciences and almost no quality library in social sciences and humanities. This imbalance also contributes to the low quality of BA degree. Karnataka is the capital of the natural sciences in the country and some of the best research institutes in natural sciences are in this state. However, we do not have such research institutes or programmes in social sciences and humanities with one or two exceptions. Unless this problem is tackled, the state of BA education will continue to remain pathetic.

As part of enriching resources, there is also an urgent need to commission books in Kannada in these fields.

SPECIFIC STRATEGIES FOR ACTION

Strategies for the Government

General recommendations

- The first two years must have some common core courses on writing and reasoning. (Suggested courses are given below.)

- The BA must be made into a four-year programme to follow global norms as well make it on par with professional courses like engineering.

- Public dissemination on the importance of humanities should be undertaken by the various government agencies with the help of universities. For example, humanities fairs much like the science fairs can be organized periodically and on a large scale by the government. Students, parents and the general public should be educated about the importance of a degree in humanities.

- The government should take leadership in facilitating the publication and availability of humanities *books in Kannada,* which are either originally written in Kannada or translated works of important texts in the humanities.

- One way for the Government to do this is to *revive the publication cells* in universities. These cells should make seminal books available at cheaper rates as well as *translate* many of these books into Kannada.

- *Change in the nomenclature* could also be considered. Instead of or along with Bachelor of Arts, other possible titles could be considered.

- *Library grants* must be given to all universities for buying books in humanities.

- Students must be allowed to *choose* universities of their choice instead of being forced to study in universities in their own localities.

- Universities must become *student-centric* and be alert to the needs of the students.

Policy Action

- Specific core courses to be introduced are as follows: Expository Writing Course (first year), Intensive Writing Course (second year), Moral Reasoning, Quantitative Reasoning, Subject specialties in third and fourth years, Focus on interdisciplinary courses, Languages, Cultures (and diversity), Indian Heritage, Gender. For the Arts students, it is important to have general courses in physical and life sciences, one common course on philosophy, one on methodology of the sciences and so on.

- Create State funding agencies to specifically support teaching and research in humanities and social sciences.

- Insist on continuing education for teachers such as high quality teacher training programmes for teachers in BA in partnership with research institutions.

- Have one academic staff college in each university.

- Make teacher training compulsory before teachers can begin teaching.

- Require that all university teachers must have a PhD degree.

- Have government scholarships for those who want to study BA. Incidentally, science students get a variety of scholarship to study sciences. These scholarships are given both by the centre as well as state agencies. Good students are encouraged to take up science. Ironically, the scholarship to science students to do BSc is sometimes more than the PhD scholarship for social sciences and humanities! This imbalance should be rectified.

Strategies for the Administration

General recommendations

- *Public dissemination* of information about social sciences and humanities is the first requisite. The students and the larger society should be made to realize the importance of these disciplines in creating not only a just society but also an ethically rounded individual who is educated in the broadest sense of the term. This means that we should create avenues where there is information on what these disciplines are about and why they are exciting in their own right. Scientists have done this job of taking science to the public and school students very well but social scientists haven't done this job. Administrators can take a lead in making sure that the information on the BA course is well presented and argued for.

- There must be a strategic attempt to do some of these activities in *Kannada*– both in public talks as well as in books.

- *Courses in Arts* – such as in music, theatre, visual arts, performance arts – must be *part of BA* courses and not taught only in separate arts colleges.

- Support the starting of *programmes in philosophy* in different colleges and universities. Philosophy should be introduced as the subject that is at the foundation of all other subjects, whether in the natural or social sciences. For example, foundations of science, history of ideas, logic could be *core courses* in BA.

- Enable a culture of respect towards teachers and students.

Policy action

- *Teacher amenities* should be independent of the courses they teach – whether it is a costly course or not should not be the criterion for teacher amenities.

- Have a teacher to student ratio on par with other courses like management.
- Review the contract system for teachers. There have been strong complaints from the teachers about this system.

- To enable research, generate mechanisms for better support for *research projects*.

- To have better teaching methods, create an *audio visual research centre* (AVRC) in each university. This will also create new education technologies.

- As part of a thorough *exam reform*, remove emphasis on essay questions; have continuous evaluation; make *project work mandatory*.

- All colleges should uniformly offer a *major and minor* combination.

- *Course structures* should be *revamped*. A degree could be in specific themes such as discussed in section III above.

- Have a concentrated effort at *integrating intellectual traditions from India* as part of these disciplines.

- *Soft skills* to be made mandatory for all BA students.

- Create avenues that will *associate teachers* in colleges with a research programme in institutions around the state. This will inculcate a *research culture* along with teaching in colleges.

- Initiate *intern programmes* for bright students to spend summers at research institutes in social sciences and humanities.

- *Establish formal networks* with such research organizations from around the country to facilitate the exchange of students and faculty.

- Have programmes which will take well known social scientists and philosophers to give *lectures* and spend time in various colleges in Karnataka. Choose one or two respected institutions and support them to administer these programmes.

Strategies related to the teaching community

General

- The science community has started a variety of *outreach programmes* such as the ones run by the Science Academy and BASE. Similar advanced programmes for social science and humanities disciplines, in order to encourage and support motivated students, should also be started. Teachers should take a lead in establishing such initiatives.

- Not only books on the relevance and importance of these disciplines but also *public lectures and talks* in schools by social scientists, writers and philosophers should be encouraged.

- Disciplines have changed the world over. New curriculum and new methods have been introduced in the teaching of these disciplines. *Multidisciplinarity* is the trend all around the world. These changes must be introduced into the curriculum of BA.

Policy Action

- Take a lead in establishing interdisciplinary courses such as Religion and Ethics, Gender studies, Folk Arts, Social Justice, Culture and Diversity, Science and Development, Globalization and so on.

- Develop a formal research programme in the colleges for teachers. Networks with other institutions to facilitate this must be established with the help of the administration.

- Arrange for visits by speakers, organizing seminars on their own research interests and other such academic extracurricular activities.

- Incorporate public service into the curriculum so as to inculcate spirit of citizenship among the youth in a secular environment.

Acknowledgement

Humanities in Science and Technology Institutes
(A Case Study of One Institute in India)

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Humanities in Science and Technology Institutes: (A case study of one institute in India) Abstract: In India, bifurcation between teaching and research has led to the creation of universities, which focussed on teaching, and research institutes, which focussed on research. This bifurcation, among other reasons, also led to the gradual deterioration of quality teaching and research in universities. A few years back the government started a series of science institutes (Indian Institute of Science Education and Research – IISER) which offer undergraduate and postgraduate programs in teaching but which also promote research like in the research institutes. In these institutes and the earlier ones in science and engineering (Indian Institute of Technology – IIT), there are humanities departments. However, these departments have often been viewed as second-class departments which were primarily there to offer 'service' courses to the science and engineering students. In this note, I discuss a particular case illustrating the challenge of integration between science and humanities departments in one of these IISERs.

Introduction

The Indian Institutes of Technology (IIT) are well known across the world. All these institutes have a department of social science and humanities but their impact on the ecosystem of the larger institute has often been quite patchy. For too long they were seen primarily as a 'service' department rather than one with their own autonomous identity and independent programs.

A few years ago, the Government of India started a few institutes in 'pure' science, called the Indian Institute of Science Education and Research (IISER), on the model of the IITs. These institutions were both a research and teaching institute with an undergraduate program in the sciences. These institutions also planned to have department of social science and humanities but the establishment of these programs has been slow in comparison to the rest of the institute.

There is a history to this development of research institutes, as against universities, in India. Post independence, policies bifurcating universities and institutes were put in place based on a misguided view that universities should concentrate on teaching and research institutes would do research. After many decades of this experiment, not only has the research output been quite problematic by any international measure but there has also been a sharp decline in the quality of education in the universities (which till recently were all government run). One exception to this was the IITs, which were both the premier teaching and research institutions in engineering. The government, spurred on by the scientific community, has also been increasingly worried about the lack of quality in science education and has thus started some institutes in the sciences similar to the IITs. These institutes are both a research and teaching institute but they are not

'universities'. So the larger lesson about the importance of universities has still not seeped into the minds of the policy makers but at least this is a start in insisting that research institutes must also do undergraduate teaching.

I have been associated with one such IISER in developing a curriculum for the humanities department. Because the leadership of the institute was very open and 'respected' the pursuit of humanities, it was easy to introduce core courses in History of Science and Philosophy of Science to the students. The science students also have to take more courses on Indian society and related themes. Having seen the impact of these courses over the two to three years and having interacted appreciably with the students and faculty on their perception of these humanities courses, there were some major issues that I felt are unique to the establishment of a humanities program in dominantly science and technology institutes in India. In what follows, I will highlight some of these issues and also some possible ways of addressing them.

Firstly, the greatest challenge in both the IITs and IISERs has been the legitimacy of non-science departments. Disproportionate number of faculty in these departments feel that they are secondary 'faculty' in the institute. The support system for these faculty is often lesser than the core science and technology faculty. More importantly, they are many times restricted in the kind of academic and teaching programs that they can initiate. I have myself seen in some of these institutes the kind of aggressive critique directed towards the non-science faculty by those from the sciences. So in the first instance there is a disciplinary tension between the sciences and the non-sciences that is pervasive in these institutes. And since all the top level academic and administrative positions are almost by default held by the scientists, it leads to having to constantly validate the humanities disciplines in the eyes of the scientists.

There is perhaps not much one can do about the mutual uneasiness between these 'two cultures'. Perhaps the best way to bridge this divide is to have public events where communities of both these practitioners discuss their disciplinary practices. But even here I have often found the scientists to be dismissive of the epistemology of the non-sciences without a proper understanding of them. As a faculty in an institute similar to the ones described above, I have seen the negative impact of this antagonistic approach by the scientists towards the epistemology of the non-sciences on doctoral students (working in the social sciences).

Rather than hope for a sensible rapprochement between individuals, I tend to believe that institutional practices are the way towards a better understanding of these communities. And among the first such practice should be to make these humanities departments completely autonomous in the sense that they will function as if they are an autonomous group with their own teaching and research agenda. Moreover, the humanities group within such science institutes must always strive to be more visible and more well-known than their science counterparts so as to balance out the inherent suspicion towards these disciplines by the scientists.

One of the ways of asserting this independence is to create innovative and useful humanities courses for the science students. Instead of becoming 'service' departments where basic 'skill' courses (such as communication English) are only taught, these humanities departments should be able to create their own teaching programs as well. However, given the challenge of working

within a science institution, they will be forced to work within some constraints in the choice of programs that they can offer. That is the reason why I believe that such humanities departments should offer courses related to science, such as science education, science journalism, art and science, and so on.

Challenges

A major challenge to these science institutes like the IISERs is that the students who come to study science subjects in their undergraduate might decide not to pursue science after all. Unlike the postgraduate and doctoral programs, where there is a higher percentage who stick on to science, it is not reasonable to expect a complete class of undergraduate students to continue with science. In fact, as part of the curriculum committee in a particular IISER, I discovered that nearly 25% of the students said that they would not continue a career in science. So if we are looking at an intake of around 100 students per year, then around 25 or more students will not continue in science. We also found that these students were apprehensive about their future and were not sure how the integrated degree (BS-MS together for five years) would help them in their career. We also felt that if this was the case in a small class, it is reasonable to expect that in larger classes the percentage of students, who want to drop out of science, might be more. We were also surprised to find that in the meeting with these students some of them wanted the option of doing their final year project in one of the humanities and social science disciplines (HSS).

What can be done to maximize the benefits to students?

First of all, introduction of interdisciplinary themes are a must in such situations. Science graduates are in demand in a variety of fields which are not directly related to research in science. Examples of different career options for a student who is well trained in science include Science Journalism, Science Education, Technical Writing, Research and teaching careers in fields such as history of science, philosophy of science, sociology of science, Technology studies, Science policy and Environmental studies. There are many new and interesting fields that are interested in science students. Students trained in these fields can get jobs ranging from academic institutions, schools and colleges, NGOs, Media, government sector and so on. These students can join excellent programs around the world in the disciplines mentioned above.

Specifically, such institutes can create new models for integrating HSS into the science stream. By so doing, it will establish new standards of responsibility towards the students who want to excel in fields other than science after having good training in science. And by allowing an autonomous HSS to flourish, the institute will enrich the research and teaching environment of the whole institute.

- Firstly, the institute should consider awarding a MS with subject specialization which will include subjects like science studies, science journalism, science and society, science policy, science education.

- The requirement for students to get these degrees are two: (1) they will do more courses in HSS compared to the general student in the science stream and (2) the final year project work

will be done in the field of specialization such as science journalism, science education etc.

- Initially, these institutes can tie up with social science and humanities institutions to send students for doing special modules in these areas as well as in collaborating on research projects.

The role of HSS courses

Humanities courses can have two functions in such science institutes. One is to introduce all the science students to the basic ideas of the history of science, the philosophy of science, the sociology of science, the relation between science and society, the ethics of science, the role of other human activities such as literature and art in the context of science, and so on. The particular institute that I was involved with did introduce history of science and philosophy of science as core subjects in the first and second year respectively. In spite of resistance from some faculty and also some students, the overall impact has been better than expected. Certain other science institutions have resisted offering these courses – when I discussed the possibility of offering a philosophy of science course for doctoral students at a physics department in one of the premier research institutes in the country, I was told that most of the faculty were not in favour of it since they were worried that the students would take it as a 'soft' course. There have been other scientists who have told me that if students get introduced to these subjects it will make them less serious about science. This attitude actually shows how scientists realize that to do science the student needs to have an unwavering belief in what s/he is doing. The worry that history and philosophy of science might wean students away from science is a well-entrenched one which I have seen among scientists in different institutes and reflects a mentality very similar to that present in religious institutions. Moreover, often these disciplines are mistakenly seen as 'anti-science'. (A well-known scientist, after hearing a philosophical talk of mine on the existence of mathematical entities asked me why I was against mathematics!)

The other function is to offer good, specialised training for those students who are not going to become professional scientists so that these science students can use their training in science to become excellent professionals in fields such as those described above. In the national context, it is important to have professionals in media, science education, science and technology studies, science policy and the like to be well trained in science as well as in other HSS disciplines. Most importantly, it is the hope that this training in the humanities will make them 'better' and more responsible and sensitive human beings – traits which are an absolute must in contemporary times.

Cultivating Artscience Collaborations that Generate Innovations for Improving the State of the World

http://wp.me/P2oVig-ik

Coordinators: Todd Siler and Geoffrey Ozin

Introduction

"Not everything that counts can be counted, and not everything that can be counted counts," Albert Einstein wisely noted. He could have been describing the subtle relationship between the intangible and tangible things that count in making any creative collaboration a success.

Commonsense tells us there are human factors, or intangible things (character, personality, "personal chemistry," ambition, inspired sense of purpose, knowledge, imagination, curiosity, teamwork) that really count toward achieving the desirable tangible things of a great collaboration (outstanding outcomes with measurable results).

In exceptional creative collaborations, it's easy to spot some wholesome habits of mind and behaviors that help enhance our understanding of one another: an openness to learn; a willingness to question what one knows or aims to know; everyday curiosity, wonder and creativity; a sensitivity to other people's views, visions and approaches to innovation; and, equally important, the essential commitment to work together in creating, sharing, and applying new knowledge to achieve a goal - one they've all chosen to pursue as gung-ho collaborators. None of these obvious things are obvious.

Creative collaborations work best when individuals share more than a common vision: they also share their mutual respect, trust and values (Buckman, 2004). The individuals engaged in these collaborations tend to constantly search for connections and common ground to cohere the complementary perspectives and practices we commonly associate with the arts and sciences. This ongoing connection making helps a collaboration continually flow like a Springtime mountain stream. Never mind whether it works as efficiently as the Six Sigma big business management strategy that Motorola implemented in the mid-1980s and that Jack Welch, the former CEO of General Electric, popularized in the mid-1990s (Tennant, 2001), the point is: To flow! (Csíkszentmihályi, 1990)

Collaborations Can Either Elevate Or Flatten Creativity

Today, collaborations of all kinds and scales power innovation in every field and industry. The most adventurous and complex ones combine a wealth of tools, techniques and innovative methods of creative inquiry, visualization and communication that draw from the intertwine histories of art-science-technology. Many integrate these resources as a form of "ArtScience" practice, uniting the aesthetic sensibilities and intellectual skills, which encompasses everything from engineering, mathematics, technology, business, and other fields of applied human knowledge (Siler, 2011)

ArtScience collaborations aim to transcend common practices of compartmentalizing knowledge. They tend to catalyze innovations grown from cross-pollinating the processes and products of one field with another. Case in point: the pioneering work in Nanochemistry of Geoffrey Alan Ozin and his international team of innovative, entrepreneurial nanoscientists and nanotechnologists. Their groundbreaking work over four decades includes the ingenious chemical synthesis of complex objects whose structure, property, function, and utility were inspired by Nature. Their novel creations not only mimic biological matter and mechanisms, they do so at the nanoscale
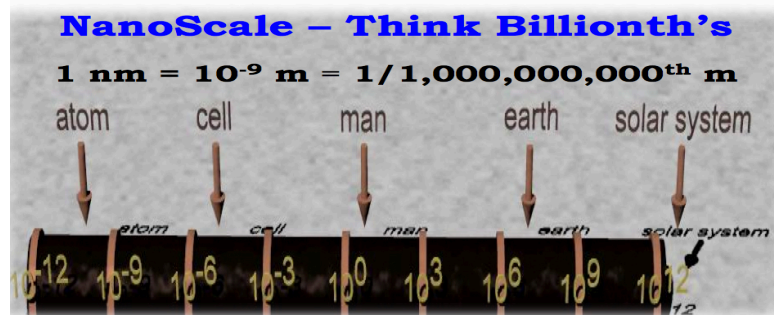(Ozin et al, 2009), where "size really matters" in remarkable ways.

Diagram of Scale Relations (Ozin, 2009)

In unprecedented ways, these nanoscientists have studied what Nature makes and what we can make of Nature. In the process, they're re-creating Nature to the benefit of humankind, while contributing to the invention of a sustainable future. This work entails generating and developing practical innovations that help improve the state of the world. It's a big feat that's, paradoxically, built on precise manipulations of atomic matter configured into miniscule machines of sorts.

The collaborative endeavor spotlighted in this paper offers one example of two lifelong practitioners in the ArtScience process (Siler, 1990) who have come together to help realize innovations in Nanoscience and Nanotechnology that can meet our urgent global challenges (Ozin et al., 2009). These two fields of human knowledge are transforming today's world, as they manipulate matter on an atomic and molecular scale, producing the tiniest human-made functional structures and systems ever conceived. These systems are designed to enhance the effectiveness and efficiency of everything from solar cells to fuel cells to computer technology to batteries to bioengineering systems with nanomaterials that fight cancers.

And that's just a cursory list of the field-at-a-glance. An expanded list would include a wide array of industries from A to Z involving Nanotechnology, such as: Automobile industries; Aviation and Aeronautics industries; Building Supplies and Construction Systems; Chemical Engineering, Computer Engineering systems, Diagnostics, Electronics, Environment & Ecology Technologies (Air, Water, Waste Management, Hazardous Waste, Recycling systems, Renewable Energies); Food Processing systems; Materials Manufacturing; Medicine and Pharmaceuticals; Military Applications for Defense Technology; Safety Engineering and Security systems, to name some.

Overcoming Conceptual Obstacles To Rise Above Roadblocks

It's been challenging planning how to best present our ArtNano Innovations not as Art for Art's sake, or Science for Science's sake, or Art for Science's sake and vice versa. But rather, ArtScience for Civil Society's sake, so to speak. That's the steepest challenge: presenting this artwork to general and specific audiences in such a manner that it conveys how this exploding field of scientific and technological innovations is growing in dizzyingly rapid ways.

When we consider the changing "tastes and appetite" of our audiences for either the arts or sciences, or both, things get seriously complicated. I caught myself virtually weighing and balancing the ratio of artistic and scientific contents of our proposed exhibition. I'd shoot these sorts of open-ended questions to Geoff and trust he'd have a wiser response than I had:

ArtNano® INNOVATION

G, Concerning our presentations of the ArtNano project to a worldwide general public:
How much do we need to say, before we've said too much?
How much do they need to know, before they feel they know too much to appreciate ArtNano innovations?
How much do we all need to see, before we've seen enough to know — and believe in — what we're seeing?
How much explicit and tacit knowledge does anyone need to absorb, before one can understand the nanoconcepts and grasp their realities in the making? As well as guide how they're wisely applied?
No one really knows. TJ

Initially, I was concerned that audiences would be overwhelmed by the abundant scientific literature on this subject; it's pretty intimidating. It felt like the technically dense science was a conceptual "barrier to entry" for general audiences, bogging down people's spontaneous experience of the fine art. I had these dreadful flashes of Geoff and I being chased by a lynch mob of art critics-at-large and "hanged" for reaching too high-and-wide in our ambitions.

I anxiously thought: Maybe we should just zero-in on one tiny, but compelling, detail of Nanoscience that I could artistically translate well in various mediums. At least, for starters.

One forecaster of high-technology markets, Lawrence Gasman, who wrote in his blog NanoTechWeb.org, expressed a similar sentiment: "Samuel Johnson once noted that the prospect of hanging "concentrates the mind wonderfully." Assuming Johnson was correct, writing a book on nanotechnology must be the next best thing to a good hanging. That's my experience anyway" (http://nanotechweb.org/cws/article/articles/22889).

Personally speaking, the biggest roadblock to our collaboration has been logistical rather than intellectual or informational. Finding the time to fully focus on a plethora of challenges that interest me has been far more challenging than envisioning Nano-solutions to urgent global/local

challenges. Naturally, Geoffrey's account of his experiences differs from mine, as he's amassed so much wisdom from working internationally with his community of colleagues.

Perhaps, the most difficult issue we're grappling with is journeying into this new frontier of knowledge with no funds, no timeframe and no team other than us two co-founders of ArtNano Innovations. Fortunately, even though we started cutting our own path to discovery with these obstacles, none have curbed our enthusiasm for this project! And that reality bears a message of optimism worth heralding. It demonstrates that even when collaborators aren't following a carefully defined goal with a picture-perfect path to accomplishing it—even when they don't have all the means or time to do it—their collaboration can still triumph. We need only look toward the adventuresome work of the visionary composer Philip Glass and the theatrical producer and director Robert Wilson whose production of their 1976 experimental opera "Einstein on the Beach" defied all the odds of success.

What does this avant-garde performance art have in common with ArtNano Innovations? Everything. That is, if you believe in this universal view: "Everything is connected." And I do, as does Geoffrey. I try to embody this worldview in my art, just as he does in his science.

Our ArtScience collaboration interprets how Nanoscience draws insights and inspirations from Nature. It investigates how Nature connects everything it creates on all scales: from the smallest structures in the universe to the largest imaginable to the human brain and creativity (Siler, 2012), which enables us all to see, discover, understand and wonder about these natural connections that "link the small and large, the local and global" (Ozin, 2012).

The artworks featured in the ArtNano Innovations intimate why and how there is no limit to the potential applications of these advanced technological innovations and the endless creative collaborations it will take to realize them aided by the arts. This project highlights the many ways in which the arts help enable the realization and responsible applications of these innovations.

Determining How To Present Real/Virtual ArtNano Innovations

Before collaborating with Geoffrey Ozin, my spectrum of exemplary, modern ArtScience collaborations was "limited." It only included everything from the creation of unprecedented technological innovations (The MIT Radiation Laboratory, 1991) to breakthrough filmmaking at DisneyPixar (Bennis & Biederman, 1997), from 3-D cinematography and computer-simulations populated by synthetic actors such as those in James Cameron's visionary film Avatar (Corliss, 2012) to sensational international SkyArt Events conceived and composed by the pioneer environmental artist Otto Piene (Glibota, 2011)—not to mention a few thousand other brilliant examples that can easily humble any innovator's ego and accomplishments!

This assortment of examples bears evidence of one overarching pattern of creativity that fits these two interrelated terms and practices: transdisciplinary thinking and integrative thinking. Essentially, these best practices of creative & critical thinking underlie the ArtScience process of connection-making, discovery, invention and innovation (Siler, 2011; Root-Bernstein et al, 2011).

"One of the hallmarks of nanoscience is its interdisciplinary nature—its practice requires chemists, physicists, materials scientists, engineers and biologists to work together in close-knit teams," write Geoffrey Ozin, Andre Arsenault and Ludovico Cademartiri, co-authors of *Nanochemistry*:

A Chemical Approach to Nanomaterials. (2009). "Communication and collaboration between disciplines will enable these teams to tackle the most challenging scientific problems, those that are most pressing in the successful exploitation of nanotechnology." Note that Nanotechnology is currently "touted as the engine of that will drive the next industrial revolution." That's no hyperbole.

Highlights of Our Learnings

The following notes serve to point out some inspiring moments of peak awareness when two collaborators transcended their individual differences to create a synthesis of sensibilities, information and vision. By "accentuating the positive" points—recalling the beautiful tune by Bing Crosby, "Ac-Cent-Tchu-Ate the Positive" which is the "key to happiness"—I mean to contrast these notes with the many negative experiences collaborators may have when any one of the Five Challenges are not addressed. Or, they're conveniently overlooked.
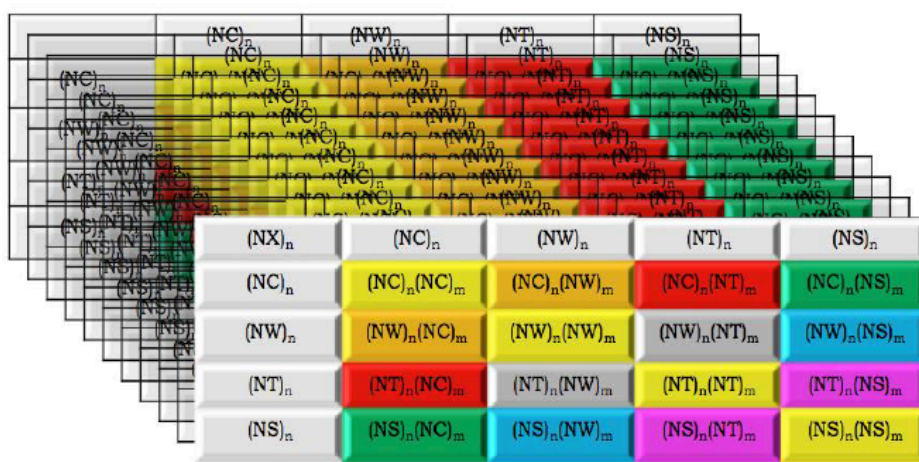
Geoffrey recently summed up his excitement for our collaboration by saying he sees "Science transformed into art." Which is inspiring. Complementing his perspective, I see Art transforming science. And when they flow together, they create ArtScience transformations that reveal, in the words of Leonardo da Vinci, "the science of art and art of science."

Building on this reference to the Italian Renaissance: The Italian word "chiaroscuro" evokes the complementary interactions Geoffrey and I experience collaborating. As we move from light to dark (from the known to the unknown) and from dark to light, we envision how our ArtNano Innovations could be presented as a variety of aesthetic experiences; each experience could emphasize one way we can re-create Nature to invent a sustainable future.

Early on in our collaboration, Geoffrey related his ideas for a new Periodic Table of Nanomaterials that he had invented, its novel 3D form fascinated me. It was unlike any periodic system I'd ever seen when exploring the many variations of Dimitri Mendeleev's Periodic Table of chemical elements. Geoff envisions creating an infinity of nanomaterials by combining four basic building elements: nanocrystals, nanowires, nanotubes, and nanosheets, as shown here:

.

Periodic Table of Nanomaterials

- The matrix of nano shapes (four main shapes are represented in the four columns and rows as crystals, wires, tubes, sheets) defines all possible combinations of shape assembly amongst like and unlike nano shapes in the most general form

- For each elemental composition and physical size of these nano shapes a similar matrix is needed that can be stacked in a regular or irregular form to represent the infinity of sizes and shapes and compositions accessible to nanomaterials

- So this is a new way of thinking about the periodic table of nanomaterials which is elegant in its simplicity yet exceptionally powerful in its potential to provide for example new energy materials for a sustainable future

$(NX)_n$	$(NC)_n$	$(NW)_n$	$(NT)_n$	$(NS)_n$
$(NC)_n$	$(NC)_n(NC)_m$	$(NC)_n(NW)_m$	$(NC)_n(NT)_m$	$(NC)_n(NS)_m$
$(NW)_n$	$(NW)_n(NC)_m$	$(NW)_n(NW)_m$	$(NW)_n(NT)_m$	$(NW)_n(NS)_m$
$(NT)_n$	$(NT)_n(NC)_m$	$(NT)_n(NW)_m$	$(NT)_n(NT)_m$	$(NT)_n(NS)_m$
$(NS)_n$	$(NS)_n(NC)_m$	$(NS)_n(NW)_m$	$(NS)_n(NT)_m$	$(NS)_n(NS)_m$

NX = nanoshape, NC = nanocrystal, NW = nanowire, NT = nanotube, NS = nanosheet, n,m = aggregation number, nanomaterial size = tier

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Geoff wondered why I was pushing him so hard to fully render a 2D picture or 3D model of what his periodic table might look like. He was envisioning something as unique as Watson-Crick-Franklin's DNA model revealing the four "building blocks of life," and I was simply curious to see what he had in mind. It was the only way I could grasp what he was seeing in his mind's eye. That clarifying visualization he created in response to this persistent inquiry helped me begin to understand the nanoconcepts and principles, and the complexities of endlessly combining the basic building blocks of nanomaterials.

Just as important as believing in the creative potential of your collaborators is seeing an openness to new ideas. Indeed, an open mind can open minds and expand them almost instantaneously. Conversely, a closed-mind can have the reverse effect. In fact, nothing flattens the joy of creative inquiry in the arts and sciences than working with closed-minds. I've seen collaborations that seemed on the surface buoyant until they sailed into an unexpected squall only to capsize and never recover. When I later did a sort of forensic analysis on what sunk the collaboration, one or more of the collaborators had closed their minds and stopped adventuring.

Five Challenges of Human Communication That Impact Collaborations

This initial list of challenges is offered as a Reality Check. Without addressing these basic challenges, individuals, teams, groups, and organizations will likely encounter countless obstacles and roadblocks. Of course, serendipity and wild dumb luck supersede everything earmarked here!

Even though these observations and comments focus on the challenges we've faced in developing our ArtNano Innovations project, they can be generalized to other collaborative enterprises involving all forms and functions of innovation. By and large, the real success hinges on continually improving human communication by fostering understanding:

1. Understanding the collaborator's aspirations and expectations for the project.

Like many spontaneous collaborations, this one just leaped into our lives and rapidly grew—in a self-organizing process—into this relatively unstructured and freewheeling idea-generation fest. And there's a positive life lesson in that, too: It's not always possible to "plan the work and work the plan," to echo that anonymous, idealized directive in business strategic planning.

Our collaboration occurred without any initial planning. In fact, it grew from a series of informal conversations and Skype chats over a period of a few months, sparked by a most unusual awards ceremony at the University of Tartu, in Estonia, organized by the World Cultural Council (http://www.consejoculturalmundial.org).

Before attending this magical event, neither Geoffrey nor I had intended to experiment in merging our professional concentrations. That simply happened. Naturally. Organically. Effortlessly. This intention started to crystallize over breakfast, following an impromptu interview the evening before with Marju Unt, Director of Estonian Euromanagement Institute, and some of her colleagues who were scoping out a program on Art & Science (http://vimeo.com/32380137). We realized we share this mutual passion for advancing innovations that can benefit humankind by posing solutions to our global challenges. Where Geoffrey aspires to actualize the "NanoAdvantage" (Ozin et al., 2009), I aspire to create or develop new art-science-technological innovations to this end.

2. Understanding the collaborators' sense of what is possible or not in the area of concentration depends on the knowledge base of the collaborators.

When collaborators from diverse fields first come together to work on a project, there are some basic questions to entertain in an informal way that can help them quickly assess one's depth of knowledge and imagination. Given that I was a beginner student of Nanoscience, I had roughly forty years of knowledge to catch up on asap, before I could pose any original, thought-provoking question that was meaningful to my mentor.

Of course, the thrill of learning doesn't get any better than having one of the brilliant pioneers in the field of Nanochemistry teach you using his co-authored textbooks that detail his team's empirical research. This one-on-one guidance certainly sustained my enthusiasm, as I learned the key nanoconcepts that concern, in the parlance of Ozin and his colleagues, the "Materials Staircase" (Synthesis, Structure, Property, Function, Utility) leading to-and-from the "Nanomaterials Staircase" (Size, Shape, Surface, Defects, Self-Assembly, Nanotech).

Without laboring to learn the basics, I would not have been able to glean Geoffrey's challenges. Nor would I be able to offer any insightful questions that we could explore together.

3. Understanding your shared goal

From the beginning, Geoffrey's goal was to use the arts to help communicate his inspired vision of what he and his colleagues refer to as the "NanoAdvantage." By utilizing various arts-based mediums, including traditional fine arts, new media, art installations and performance art, Ozin aims to engage specific and general audiences worldwide in his thought-provoking public presentations that highlight the evolution and growth of Nanoscience and Nanotechnology. We plan to make a selection of his lectures on the NanoWorld and the NanoAdvantage available.

"One can experience the NanoAdvantage for example over the entire platform of material energy systems, where they may be engineered for solar cells, fuel cells, batteries, supercapacitors, thermoelectrics, piezoelectrics; and where the enhanced performance relative to their macroscopic counterparts always goes to one-and-the-same 'heart of the matter,' the NanoAdvantage" (Ozin, 2011 & 2012).

My goal was to help Geoff accomplish his goal with the aid of the arts. Beyond that, I wanted to experiment with the various nanomaterials in my artworks—in particular, the photonic structural colors (Ozin et al., 2009). I love experimenting with new materials as it often yields many "aesthetic accidents" and discoveries. Moreover, I wanted to work my deepest passion for human neuroscience into our project, because that was most important to me. Actually, it's the hallmark

of my artwork and the center of my research for decades: connecting everything human-made to the hidden work of our minds and the brains that shape our creations.

It's important to me that our audiences do not have to immediately understand the science to embrace the art. That deeper understanding and appreciation comes naturally, as viewers learn to seek-and-see in the art the scientific concepts embedded in it. Here, science isn't explained or illustrated. Instead, it's experienced and interpreted as myriad forms of art. Anyone with an open-mind and curiosity can grasp the beauty of wonder and wonder of beauty expressed in the nature-inspired ArtNano innovations. Anyone can experience seeing these artworks beyond categories, and experiment with their countless everyday applications for enriching our lives.

4. Understanding what the Work of Art and Work of Science mean to you.

One process of innovation and creative inquiry I've been experimenting with since the mid-1970s involves playing with various interpretations of formal works of "Art" and works of "Science" that were characterized as such, I would either add scientific information to the artwork, or subtract information from the sciencework. The net effect was always aesthetically startling and refreshing! The art became science, and the science became art.

Some 36 years later, I find I'm still absorbed by that fundamental transformation of information (data, knowledge, ideas, concepts, events, etc.). It delights me to see how central this transformation is to the phenomena we call "aesthetic experience," in which all sorts of natural ambiguities arise that can't be explained away or described with words and numbers alone. As the mind gropes to grasp what it's experiencing, there are so many "simple pleasures" to enjoy. More often than not, these experiences inspire us to dream and imagine endless possibilities.

In my practice of art making, anything goes because imagination goes with everything! Art is not only what you make, it's what you make of it, too. That same truth holds for those who are open to experiencing science, technology, engineering, and mathematics in this open-minded manner. When we allow our imagination to experience things without categories, compartments, and limits, we're able to discover how Art, or A.r.t., encompasses All representations of thought. It's the sum of human knowledge, endeavors and experiences. It embodies everything that human beings can and do connect with, as we link Art to the whole of Life-Reality-Nature.

ArtNano Innovations invites viewers to experience those unpredictable, "aesthetic accidents" that underscore most original discoveries. Albert Szent-Gyorgyi, the 1937 Noble Prize-winner in Physiology or Medicine, once noted: "A discovery is said to be an accident meeting a prepared mind." The art here aims to prepare our minds for that unexpected encounter with discovery.

As I discussed with Geoffrey at the outset, I wasn't interested in making a show-and-tell style Science Fair out of our creations. We agreed to create unique "aesthetic experiences" that may not resemble the explicit scientific visualizations we're familiar with. Moreover, the art aims to integrate the compartmentalized worlds of Nanoscience and Neuroscience, among other areas of physical sciences It explores the possibilities of a unified field of knowledge that is quint-essential to human development and the advancement of science-technology-engineering-mathematics and civil society.

Many of my artworks consider unique perspectives on Nanoscientific challenges as seen in the broader context of human/nature relations. They evoke these natural linkages between the Nano-Neuro-World of interrelated forms and processes (Siler, 1990). ArtNano Innovations recognizes the connections between Neuroscience and Nanoscience, highlighting the hidden handiwork of the human brain that is often left out of our big picture interpretations of Nature. Expressed another way: The art embodies nature-inspired ideas, concepts, hypotheses and theories on the creative work of nature and the human imagination that ties everything together in new and purposeful ways.

5. Understanding the different "learning curves" of the collaborators.

There's always a learning curve in any collaboration, which affects the speed of development and realization of the project. Regardless of how knowledgeable, wise, intuitive, or experienced a collaborator is, it takes some time to learn new concepts and process their implications, and then act on this knowledge intelligently with strategic and tactical plans. I would extend this observation to our audiences, as well. This remains a huge obstacle to any casual viewer's appreciation of these ArtScience productions: grasping the "artistic" dimensions of science, and the "scientific" dimensions of art. Also, there are plenty of curves in the way we try to grasp things by surmising what they look-and-feel like or mean, judging from our limited interactions with them.

I found it was time well spent mulling over the core concepts and principles rendered in Geoffrey's textbooks, just as he delved into learning about my exploratory artwork. It took me awhile for this counterintuitive reality to really sink in: "There are no new nanomaterials. Rather, they are just reconstructed forms of known materials [from the Periodic Table of Elements], which can be sculpted at the nanoscale," as Geoff has written. "All the atomic compositions and atomic arrangements of the materials are known. But it is their physical size and shape and accessible surface properties plus their self-assembly into purposeful higher tier 'panomaterials' with structural features formed over multiple length scales, from nanometers to millimeters to centimeters to meters and beyond that creates, for example, the NanoAdvantage as intimated by this work of ArtNano Innovations" (Ozin, 2011).

Summary

We all have our own questions that we'd like to answer because they engage us in personally meaningful ways. I'm sure the questions that absorbed me are not necessarily the same ones that Geoff dwells on professionally and has challenged his research team to respond to in great detail. For instance, I cannot explain why I'm interested in exploring these kinds of basic questions:

- What natural and/or artificial forces make all nanomaterials self-organize? Is there one general or overarching pattern for self-organizing nanowires? Is that pattern of growth similar to what may be observed in nanocrystals, nanotubes and nanosheets, as well?

- Are there archetypal patterns to the growth of all nanomaterials?

- Do all nanomaterials self-organize the same way, whether they're crystals, wires, tubes or sheets?

- Do different types of nanowires self-organize at different rates of growth?

By contrast, Geoffrey and his colleagues are currently tackling these big issues:

- How do abiological chemically powered nanomotors work?

- What is the origin of motion in these particular nanomotors?

- How do we fully represent nanoscale hydrodynamics theory?

- How do the size, shape and surface of a nanomotor, solvent viscosity and temperature, control the velocity and ultimate speed limit?

- How do we control the direction of nanomotors: chemotaxy, magnetic, electric, optical fields or other means?

- How do we get nanomachines to work purposeful and reliably?

- What jobs (e.g., cargo pickup, delivery and drop off) do we want nanovehicles to carry out?

- What tasks, such as seek and destroy tumors, environmental sensing, medical diagnostics, pollution control do we want them to perform?

- What is next - perfect size and shape and surface to get perfect control of nano locomotion?

- How can we use a non-toxic fuel, water, to power nanomotors?

- What are the mechanisms underlying the phenomenon of swarming, or collective motions and cooperative interactions?

- How does swarming occur? Like bacteria swarms and related biological systems? Are they communicating through chemical signals vis-a-vis concentration gradients?

As Geoffrey re-draws my attention to his challenges, he knows me well enough now to know that I just don't want to be a science "visualizer" of physical phenomena—infusing fresh perspectives in mostly illustrative scientific visualizations of Nanotechnology. I aspire to go much deeper into this subject matter and actually contribute to the design and development of Nanotechnology. Naturally, this aspiration requires me to rigorously study these innovations, in order to understand their design principles and general dynamics:

Finally, if it were possible to create "perfect" human communication and understanding, anyone could understand everyone at any given time. Every human being would possess the capability of grasping the ideas, insights, knowledge, and experiences of our fellow human beings by virtue

of some neuropsychological "black box" translator/ communicator: a nanotech tool designed to help anyone make sense of anything (data, information, knowledge, concepts, theories, etc.). I'm sure the visionary Serbian-American inventor Nikola Tesla, who dreamed of operationalizing telepathy, envisioned the possibilities of such infinitely versatile and practical tools. Fortunately, Tesla wasn't the only futurist innovator thinking of a technological solution to helping human beings understand one another better and communicate perfectly. Google's language translator is getting mighty smart and sophisticated about this too, as advancements in Internet inference and search engines leverage the semantic engines that make sense of seemingly random "unstructured data on the World Wide Web" (http://www.redbooks.ibm.com/abstracts/redp3937.html)

Clearly, we don't live in anything close to an ideal world of human communication. If we did, I'm inclined to believe it would be considerably more harmonious. Simply, everyone would be a lifelong learner. And creative learning would be as easy as breathing, which we're hardly aware of it until we stop to appreciate it in a flash of higher awareness.

Working with Geoff Ozin is as close to having an ingenious translator of *all things art into science* and *all things science into art* as I've experienced in only the rarest of occasions. This inspiring collaboration points to ways we can transfer our key learnings into some intuitive tech tools that can leverage the best of our collective thinking on innovation. As Geoffrey and I learned, it's important to reflect on upbeat scenarios of a better world in which we realize human/nature's potential, as we cautiously reason: If Nature can do it, humans can, too; if it exists, it can be synthesized.

References

Bennis, Warren, and Biederman, Patricia Ward with Foreword by Charles Handy. (1997) Organizing Genius: The Secrets of Creative Collaboration. Reading, MA: Addison-Wesley Publishing Company, Inc..

Buckman, Robert H. (2004). Building A Knowledge-Driven Organization. New York: McGraw-Hill.

Corliss, Richard (May 17, 2012). "The 10 Greatest Movies of the Millennium (Thus Far)". Time.

Csíkszentmihályi, Mihaly (1990), Flow: The Psychology of Optimal Experience. New York: Harper and Row. ISBN 0-06-092043-2

Glibota, Ante (2011) Otto Piene.,Grafiche Tintoretto, Villorba(tv), Italy: Delight Edition. ISBN 978-988-19532-2-3

Ozin, A. Geoffrey, Arsenault, Andre C., and Cademartiri ,Ludovico, (2009) Nanochemistry: A Chemical Approach to Nanomaterials. Toronto, Canada: Royal Society of Chemistry and University of Toronto, p. xviii

Ozin, A. Geoffrey (2012) "Photonic Colour. Lab-to-Market." Materials Chemistry and Nanochemistry Research Group, Center for Inorganic and Polymer Nanomaterials, Chemistry Department, University of Toronto, Ontario, Canada (www.Opalux.com)

"The MIT Radiation Laboratory - RLE's Microwave Heritage", RLE Currents, v.2 no. 4, Spring 1991

Siler, Todd (2012) "Neuro-Impressions: interpreting the nature of human creativity," in Frontiers in Human Neuroscience (www.frontiersin.org) October 2012 | Volume 6 | Article 282

____. (2011) "The ArtScience Program for Realizing Human Potential," in LEONARDO, Vol. 44,   No.5, pp. 417-424.

____. (1997) Think Like A Genius. New York, NY: Bantam Books.

____. (1990). Breaking the Mind. New York, NY: Simon & Schuster.

Root-Bernstein, R., Siler, T., Snelson, K., Brown. (2011). "An ArtScience Manifesto," Leonardo Journal of Art, Science, Technology, June 2011 Issue (Cambridge, MA: The MIT Press)

Tennant, Geoff (2001). SIX SIGMA: SPC and TQM in Manufacturing and Services. Gower Publishing, Ltd.. p. 6. ISBN 0-566-08374-4; And "The Inventors of Six Sigma"

Complexity Art: A Pattern of Transdisciplinary Emergent Properties

http://wp.me/P2oVig-jU

Coordinator: Myriam Solar

Overview

In the search for a strategic alliance between art, science, technology and nature are facing a new domain of research and contemporary practice in which art ceases to exist as a copy of nature or inspiration of scientific principles to work as does the natural organic world. Since this essential principle that seeks to build structures for dynamic interaction and collaborative systems, the art of complexity can become an important field of transdisciplinary research, able to bridge between disciplines that explore the frontiers of knowledge, which together with a re-conceptualization of the artistic discipline itself push their limits in the direction of objects and common problems. This perspective raises an historic opportunity to build foundations and develop a partnership based on a new conception of the research in which disciplines can work in broader contexts with models and methods that transcend them in front of open worlds of emerging fields.

In this challenge, and in response to the call of SEAD in its interest to know the lessons learned from the prehistory of the pioneers in working with science, it is pertinent to sketch work pioneer of the Author by her findings, innovations, aesthetic creations and potential applications in fields of technology, of knowledge, aesthetics and culture.

The paper includes, therefore, a brief introduction to her creative practice focused on the systemic nature of art in interaction with basic sciences, emerging fields and technologies; at the same time which underlines their role at work with the culture of research, the education of society, science and technologies. This framework proposes a model of art of the complexity of emergent properties built on the basis of the interaction at the frontiers of knowledge, which implies a reformulation of the art, its foundations and methodology. The proposal brings with it a new thought capable of identifying problems and support mechanisms that allow to give a step forward for achieving results. In this regard, advances the idea of a common space for emerging areas between disciplines and is set a provisional table of them around which artists and scientists could develop clouds of joint creativity and find the necessary sources of inspiration for subsequent programmes. At this point, and given that current developments are scattered, are little known and emerging, the Author suggests a set of actions aimed at global strategies that woul have that taken into account in the elaboration and implementation of specific programmes which would allow in successive phases promote a fruitful transdisciplinary collaborative work with sciences and technologies.

The art of complexity, creativity and research

The art of complexity works away from the balance - just making it the nature and the universe - through dynamic processes of complex interaction including probabilistic and irreversible changes in time. Its creations are organisms to a new level of complexity that contain systemic

creativity or ability to combine elements that will grow and develop in an environment open to its own evolution.

In this way, the art of complexity can provide to art, that this has not so far as I know: an own experimental practice on a complex, multiple, material object which are derived from theoretical concepts own and shared with the disciplines of interaction; what it must allow systematizing the object and find areas of common interest for transdisciplinary collaboration with sciences and technologies.

With the advance of time, both art and thinking about the investigation have been changing towards new ways of conceptualizing and opportunities which, however, in the early days, was clearly unfeasible due to the weight of tradition that ran by opposing paths, the cultural gap and knowledge existing within the discipline itself and outside it.

I shall discuss, therefore, first-person on research in the complexity art - because it is my own field of work - dealt with solo and experimentally. Towards 1987, when I started without known theoretical references, neither staff nor supporting institution I discovered an unknown world for art expanded towards other fields linked to science and technology. The road was replete with difficulties and problems by what the task made me somewhat chaotic and painful to not having a transdisciplinary frame provide me explorations and will help me to understand what was happening in my study-laboratory. It can be said that the initial findings I were placing in a corpus of large-scale further than the search for beauty in art, which led me to try to develop a program of systematization of the sources linked to fluids, the element water, technological devices, natural and not human languages, geology and their potential applications.

For a long period of time I documented experimental sources and identified the emerging fields of character transdisciplinary with which the complexity art appeared to be related. The materiality of artistic representations and experimental sources of dynamic nature that I had discovered had no known history. Da Vinci was the only prior precedent on fluid I could find relating to my main subject: water, and although their findings had little to do with mine, however, I served as a guide and above all gave me the confidence to know that was on the right track. Then I found to Perrin, Mandelbroth, Prigogine and many others who helped me to investigate further, while I was learning from their disciplines and enlarged my own thinking and universe of research into all possible scientific fields that the sources seemed to have relationship. I compared their descriptions and observations with my own findings and constructed a theoretical scaffolding linked to fractal geometry (1), the strange chemistry of water, artificial intelligence, biology, quantum physics (2), geology and animal studies.
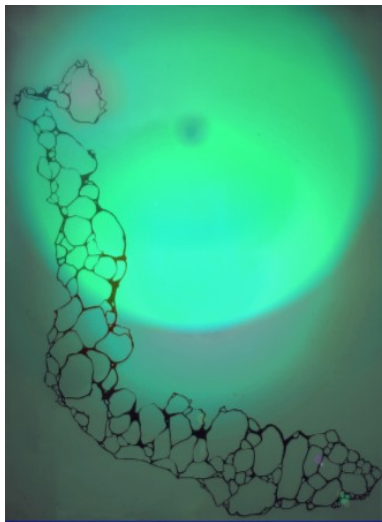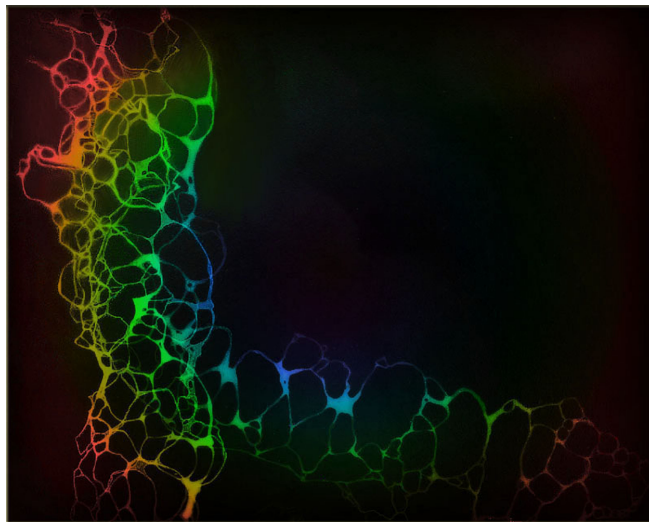
Figure 1   Figure 2

1.Green Dragoon, natural fractal created by self-similarity, aggregation and percolatión on the water, Zolar© Science & Math-Next Big Idea, NM(2011) and 2. Multiple Structure and Networks, natural and digital fractal, Zolar©.

Figure 3   Figure 4

3.Strange Attractor, natural fractal object in movement result of the simultaneous order and the chaos on the water, Zolar©, Science & Math-Next Big Idea, NM(2011) and 4. Supramolecular Pavilion, DVD collection of superstructures of molecular nature, self-assembly and clusters, sets of double interaction with fixation,entropy, cooperative effects, construction of parallel blocks, species or structures fixed with bond, rings or cycles of oval geometry corresponding to biological systems and great superstructures with host and guests, Zolar©, Chemical Reactions, Central Booking Gallery, N.Y.(2010).

In these first fifteen years of working with emerging fields I realized finally that I was in front of a new domain in the field of the Sciences of complexity; the Art of Complexity and the Aesthetics of Complexity, so I called it in 2000 (3), consisting of conceiving a new physical reality: of the organic form from dynamical systems in art and its potential future.

The challenge and fascination that came to exert on me that reality led me to discover something that is shown in figures 1 – 4 like self-organization processes, the formation of structures and networks, principles of form design and project of organism, autonomous universes of natural and artificial organisms in open systems, general dynamics of natural structures in living systems and primary organizations, the geometric essence of physical and chemical chaos, colour, volume and organic form, the morphological elements of natural fractal language, Natural Fractals in art (4) and cellular systems, the 4th dimension in the complexity art, multiple geometries, quantum States, the intelligence of the complex dynamics and its potential application to technological devices.

From these major challenges I went to the aesthetics of complexity and biodiversity where my concern focused on the development of techniques able to present each new artistic category founded by me and each artwork containing such complex objects without that the viewer would be disturbed by their scientific or technological nature.

This explosion of knowledge led me, finally, to conceive of various possible scenarios where show the aesthetics-scientific findings which would hurl its potential research in education, in the new languages of the literature of a third culture (5), the new aesthetics of biodiversity and complexity art. This was how I conceived in the field of contemporary art, the creation and implementation of the international curatorial programme Complex Projects composed of a transdisciplinary avant-garde art space focused on the complex intersections of complexity art, an international discussion table in which connected transdisciplinary concepts and realities seeking to create a state of favourable opinion on new developments, articles about aspects of my research in art magazines and the web-Museum Biofractal e-Museum on this discipline. The latter, a project in stand-by, advanced for the time and the place, had to necessarily failing against the existing gap and lack of support. Open to the scientific community, the project was conceived as a global, artistic-scientific and educational webMuseum to learn how to build and investigate, driving the thinking of creativity of the natural world, the Arts, Sciences and Technologies.

Complexity Art: transdisciplinary Pattern and emerging areas

In the first decades of the new century, the precarious situation in collaborative research, orphanhood of scientific artists, the gap and lagoons on discipline -- as in latitude you are -- it have not changed radically, despite the resources available and to the progress of knowledge in the transdisciplinary direction.

This state of affairs brings with it a scientific artistic stagnation that affects the attempt to bypass a transdisciplinary collaboration, while actions by changing things continue being matter isolated without recognition or support of the scientific and cultural community, which delays or hinders any progress that should be undertaken from a new creative practice.

At this point it seems clear that transdisciplinary dialogue requires previous steps by the actors involved, who have noted the key aspects that lead to rethinking of new scenarios, opportunities and approaches towards potential future of exchange between disciplines.

In what art refers, these steps should correspond to a reconceptualization of the artistic discipline itself, its rationale and methodology where arises the new nature of the art object, develop a theoretical body capable of realizing the reality of the new languages, revise its procedures and multidisciplinary approach is changed to the transdisciplinary.

It would be a real aesthetic and epistemological turn in the conception of the arts that cease to be static to become dynamic and complex in a universe of processes, organisms, interactions, multiple, mutable, virtual, polysemic and indeterminate forms in spacetime. On this axis Guide could begin to think about incorporating the languages of complexity to the traditional scheme of the arts, and jointly articulate an inclusive model of practices, methods and experimental research in those emerging areas susceptible of collaborative transdisciplinary development.

The resulting model should be open to the evolution of the growing organized complexity of objects in nature, dealing with science, technology and the arts alike. In this dynamic, the changes correspond to the nature of the creative processes that move the vital centers of artistic practice into what is alive and evolving, while they draw a future of research on a common basis that is similar to the creation of objects of knowledge, whether scientific or aesthetic.

This pattern is found in the art [and aesthetics] complexity capable of addressing objects as physical phenomenon integrated to other systems away from the balance and non-linear evolutionary process. In the new art model it ceases to exist as a copy of nature and inspiration of scientific principles or technique application to the sciences to work as does the natural organic world and, therefore, science. Since this essential principle can think in collaborative science and technology bridge, to treat common objects for scientific purposes in a case and aesthetic in the other, or both at the same time. It tries to find a rich path that explore frontiers from experimental practice where art assisted by science, technology, engineering or design and / or science assisted by art cease to be of aggregates or complements one another to perform a job with new interaction strategies, since both art and science involved in a common search in their understanding of the world.

The potential of the new front requires, therefore, a new thought capable of identifying problems and support mechanisms for the development of intersections in the emergency of new. To which artists and scientists should know fields susceptible of an eventual collaboration through a specific agenda for action that will allow sketch a transdisciplinary picture of objects of research in common areas.
From the complexity art we can configure a provisional table of emerging areas around a new common space derived from the processes of exchange between disciplines. To this emerging space, complex art can bring its own theoretical conception and experimental procedures - intuitive at times, others simple invention, dynamic visualization, cognitive interaction, multilevel comparative strategies, non-programmed experiments and improvisation against random and chaos and the scientific method itself - as applied to objects of research could

provide advantages in a process of transdisciplinary Exchange, by providing sources of inspiration for or solutions to problems that have been unsolved.

As an example of collaborative initiative in the complexity art, and the mode of the STEM fields (6) a lack of an acronym that describes it, emerging areas that promise a job for transdisciplinary can be grouped around: mathematics, chemistry, biology, artificial intelligence, quantum physics and new fields by defining that they point geology, semiotics, and ethology, among others.

The new transdisciplinary common space could explore from these new fields, where the prospects of complex arts are potentially high to begin a fruitful and creative collaboration. Initially to make this happen would have to define domains, roles of the actors involved, pilot programs, autorship and copyright as well as procedures for participation in projects in order to maintain an active virtual network where artists and scientists could bring new ideas, activities of approach that will help build provisionally that transdisciplinary common space collaboration between artists and scientists.

Suggested actions

1. Problem: Reformulating the artistic discipline and reconceptualizing the role of the Arts in the 21st for a third culture that doesn't exist yet where are integrated art, science and technology.

1.1 Action: Designate an academic transdisciplinary Committee responsible redefine discipline artistic in the field of the Sciences of complexity as art and aesthetic complexity, developing the nature of the object, its theoretical principles and its methodology as well as curricular programs for upper grades that include introductions to the history of science, philosophy of science, the scientific method, principles of the Sciences of complexity, frontiers scientific domains,etc.

1.2 Shakeholder: educational institutions, educators, academies, artist - scientific.

2. Problem: The current dispersion of knowledge that scientists artists have generated in its approach to transdisciplinary, and, in particular, in the field of the art of complexity, must meet somehow in a virtual centre as the basis for the advances of new initiatives.

2.1 Action: Designate a Virtual Committee which is responsible of reconstructing the prehistory of transdisciplinary labour made by scientists and artists, and especially in the art of complexity, through a specific agenda that incorporates emerging domains, lines of research, profiles of researchers artists with a view to the creation of a Centre of Transdisciplinary Research that should unite efforts, projects and activities in the new direction.

2.2 Shakeholder: New organization as a global platform Sead or Virtual Global network or agency of new creation consisting of science educators, scientists, and artists.

3. Problem: Stress discipline between science and the arts generates mistrust and lack of acceptance of artistic work by the Community scientific or vice - versa, generally based on a mutual ignorance of such work where new thinking is how to bridge new strategies of interaction between the complex art and emerging fields with the sciences.

3.1 Action: Create a virtual database as well as a permanent virtual curatorial space of diffusion on the explorations of borders in the transdisciplinary artistic practice corresponding to emerging fields.

3.3 Shakeholder: New organization as a Sead global platform or Virtual Global network, or agency new creation integrated by educators, scientists, research centres and artists scientists in emerging areas, websites on the Internet.

4. Problem: Characterize and define the new common transdisciplinary space emerging fields and their leaders to connect with scientific experts and centres of research in these fields, identifying opportunities for the development of transdisciplinary collaborations.

4.1 Action: Creation of a global digital record that incorporates emerging fields, names, lines of research, calls for collaboration centres specialized or scientific, funds for projects, obtaining information from databases created with the objective of bringing together the best talent among artists and scientists in new domains.

4.2 Shakeholder: New organization as a global platform Sead or Virtual Global network or agency of new creation where the members, educators, scientists, centres of scientific research and artists can incorporate their work, opportunities for collaboration, new ideas, activities, etc.

5. Problem: How to stimulate not sporadically developing transdisciplinary collaboration in established and emerging areas from art.

5.1 Action: Create support funds that stimulate collaboration continuously and projects opened in emerging areas.

5.2 Shakeholder: Foundations, government agencies, universities, research centres.

6. Problem: How to deal with the aspects critical to the advancement of the collaboration transdisciplinary art such as methods and tools work in dynamical systems, human-not human interaction, viewing and recording.

6.1 Action: Create pilot projects focused on new methodologies, development of forms of visualization and visual record.

6.2 Shakeholder: Universities, Center for transdisciplinary research of new creation, scientific artists.

7. Problem: The creation of new avenues and its maintenance need of institutional and financial supports that do not yet exist as the new platform of point 2.

7.1 Action: Provide the necessary institutional and financial support focused on new organization networks.

7.2 Shakeholder: Foundations, science academies, research centers.

8. Problem: How to create opportunities for collaborative transdisciplinary development oriented to the creation of new products.

8.1 Action: Maintain a record of seeking opportunities in emerging fields for industrial purposes.

8.2 Shakeholder: Industry, engineers and philanthropy.

References

(1) Solar, Myriam. Mathematical complexity of the water(2011).Festival of Discovery, Invention & Innovation, Science & Math, Next Big Idea, 2011 Smart Sampler, Los Alamos, NM, 2 finalist works Scimath in Flickr.
http://www.flickr.com/photos/58657425@N03/sets/72157626562751942/?page=3

(2) Solar, Myriam. The quantum dimension of the complexity art and its interacting quanta(2009). Plastik [Art & Science] 01, Etre ici et lá:la relativité générale et la physique quantique, Université de Paris-1 Pantheon-La Sorbonne, France. http://art-science.univ-paris1.fr//document.php?id=164

(3) Solar, Myriam. Arte de la complejidad: aleatoriedad, fractalidad, caos (2000). Mecad e-Journal Nº 4 Arte, ciencia y aleatoriedad, Barcelona.

(4) Romero-Tejedor, F. Van den Boom, H. Fraktale in der Kunst.Myriam Solar:Das Beispiel einer fraktalistischen Künstlerin (4/1997). Offnungszeiten Papiere zur Designwissenschaft, Universiteit de Braunschweig der Hoschschule für Bildende Künste, Braunschweig.
http://www.fhluebeck.de/Inhalt/03_Hochschulangehoerige_Ch031/04_FB_Elektrotechnik/04_Labore_und_Institute/18_Labor_IGi_Designlabor/O__ffnungszeiten21-07Web.pdf

(5) Solar, Myriam. El big bang y el territorio de la complejidad en la poética cuántica(2010). EXP Experimental Poetics and Aesthetics Nr0, University of Canterbury, New Zealand. http://experimentalpoetics.com/blog/el-big-bang

(6) Mitchell, William, J., Inouve, Allan S. And Blumenthal, Marjorie S.(2003). Beyond Productivity: Information, Technology, Innovation and Creativity. The National Academies Press, Committee on Information, technology and Creativity, National Research Council. http://www.nap.edu/openbook.php?record_id=1067il&page=R1

Opportunities and Obstacles Facing Scientists, Mathematicians, and Engineers Deeply Engaged in the Arts and Design

http://wp.me/P2oVig-rs

Coordinators: Carol Strohecker, Roger Malina, Wendy Silk

http://seadnetwork.wordpress.com/white-paper-abstracts/abstracts/opportunities-and-obstacles-facing-scientists-mathematicians-and-engineers-deeply-engaged-in-the-arts-and-design/

Introduction

Efforts to combine distinct entities, such as knowledge disciplines and organizational structures that have grown to pervade them, suffer from a seemingly inescapable dilemma: the terms of discussion inevitably invoke the very entities and mindsets we attempt to surpass. We try to move toward a new paradigm, yet speak in terms acculturated by the current state of things. Rooted in habits of thought and action, these terms have a stubborn tendency to recur and persist. They can inhibit the desired synthesis, ironically serving instead to reinforce the customary separation.

An imagined new reality is difficult to grasp. Once achieved, it would have its own terminology based on an evolved set of assumptions. How could our innovative predecessors have predicted proliferation of the "car" when all they could see was a "horseless carriage" – not even yet an "automobile"? We are limited by currently available concepts and terms.

So it is with discussions of "art/sci" and our attempts to leverage, through synthesis, knowledge from realms conventionally kept apart. The stakes are high and separations run deep, constituting personal and professional identities, forging career trajectories, and shaping destinies among professional generations to come.

This issue is inherent in the entire collection of SEAD White Papers. Nevertheless, we strive at least to ensure thoroughness in the discourse by including views and vocabularies from many relevant perspectives. In this particular paper, we turn from education, arts, and technology to perspectives of researchers working in realms traditionally designated as scientific, or pertaining more broadly to the STEM (science, technology, engineering, and mathematics) disciplines. These areas are increasingly characterized by interdisciplinary studies, many involving fields commonly associated with arts and design.

We approached individuals who have become known for working in this cross-cutting way and asked them to participate in focused discussions based on a given set of interview questions. These questions appear in the Appendix. We conducted some of the interviews through face-to-face meetings in person or online, some through telephone, and some through email correspondence. We addressed the same 27 questions in all the interviews.

Altogether, 20 scientists participated: 7 women and 13 men. One of the women says she may be more artist than scientist, having started her career as a concert music composer and in the visual

arts – yet, through many years of collaboration with scientists, she has developed sophisticated knowledge in materials science, quantum equations, and knot theory. One woman and two men say that as individuals they embody both the artist and the scientist for a significant amount of their work. However, the majority of respondents educated in traditional silos of scientific theory and practice, and for some of their work now collaborate with self-identifying artists and/or designers.

The respondents represent a wide range of disciplines, their chosen fields reflecting individual inclinations and interpretations of the meanings of science and work. Idiosyncracies abound. Despite our attempt to maximize comparability of the responses through consistent interview questions, the scientists responded selectively and with varying degrees of detail. At times the responses flow from one category to the next and at times they become free-form, as respondents added their own spins on the material.

Nevertheless, through the participants' reflection on motivations, methods, and results of their work, we have amassed a rich and informative body of information. The respondents spoke generously, informally, and from direct experience. The views they express are unabashedly personal and perhaps all the more informative for their frankness.

Interview Responses

Only half of the respondents describe their field with a single disciplinary term; the others name multiple scientific disciplines that constitute their work. Four are cognitive or visual neuroscientists and another four identify their specialization as scientific and/or data visualization; one also mentions sonification. Other disciplines represented include: astronomy, astrophysics, atmospheric science, oceanography, geology, mathematical biology, computational cell biology, evolutionary biology, population genetics, animal behavior and communication, bioacoustics, biomechanics of movement and locomotion, entomology, physics, materials science, applied mathematics, communications science and engineering, computer graphics, and human-computer interface engineering.

All but two of the respondents identify additionally with an art discipline, which they practice on their own. These disciplines include sculpture, woodwork, printmaking, mosaics, collage, visual art, architectural drawings, graphic illustration, technical drawings, photography, videography, animation, computer graphics, holography, theater, dance, choreography, improvisation and performing arts, poetry, music performance and composition, and fashion design. Interestingly, one respondent identified teaching as an art and another simply noted "smell" as the chosen art form.

Several respondents elaborate multiple disciplines inherent in their primary field, as in neuroscience. Others name additional scientific disciplines they seek to involve through collaboration or on their own as their research proceeds.

All the responding scientists have been working collaboratively with artists and/or designers for 5 years or more, some for as long as 20 years or more, with one reporting such collaboration dating back about 50 years. Motivations include: seeking new viewpoints; learning new ways to

express ideas; pursuing research on human sensory and cognitive systems; creating alternative ways to explore scientific data; finding new metaphors for understanding scientific phenomena; supporting designers through creation of computer-based tools; teaching about multifaceted topics, such as color; engaging public interest in science; educating students formally; and educating the public broadly.

Scientists report that their collaborations with artists clarify conceptualization and understanding of scientific problems and results, yield new approaches to questioning and experimentation, improve teaching style, enable fresh views of familiar theories, reveal underlying structures and patterns, introduce alternative formal systems for communicating principles and results, go beyond static representations to dynamic time-based forms enabling new modes of analysis, and improve the social settings in which scientific research is conducted.

Many of the respondents find artistic modes can provide a bridge to more general understanding, rather than contributing to scientific advances. However, an evolutionary biologist says, "Instead of using the same old hypothetico-deductive approach, I've come to consider the benefits of an exploratory approach, not knowing beforehand what I was looking for." The co-author of children's books about marine ecology comments, "The process of simplifying concepts to their essence ... was helpful to me in thinking about my own research." And an astrophysicist says, "Colleagues have inform[ed] me that they use the methods we've reported in a journal paper or the information I have placed online for their figures."

One of the data visualizers believes her representational modalities and practice of interdisciplinary collaboration can encourage scientific discovery by reducing abstraction:

> In our research we are discovering that the potential for scientific breakthroughs [is] definitely there. If we can make a language that allows our scientists to assimilate very complex information visually and sonically, they may be able to speed up their time to new discoveries by building on this language and comprehending even more abstract information. Our psychologists tell us that multimodal representation of information leads to long-term memory, hence scientists may find a "formal" way to be intuitive about their research.

A biologist confirms this potential through his description of an NSF-funded mathematical model developed through art/science interdisciplinary collaboration: Displaying results of the simulation through dynamic visualization, the collaborators showed that positive feedback loops between savanna trees and fire frequency can stabilize the ecological context and sustain characteristic vegetation.[1]

A neuroscientist who collaborates with a comic artist reflects on how the work influences his scientific practice and his understanding of its place in society:

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1 Catherine Crawley. Trees Facilitate Wildfires as a Way to Protect Their Habitat. NIMBioS, 29 Oct 2009.
http://www.nimbios.org/press/NIMBioS_release_102809.pdf

Our work does affect my approach to science, and I am surprised at this because I would not have predicted such an outcome. The main practical benefit I derive from working on the comics is that each is like a minireview on a topic area, thus it gives me an updated view on the state of the art in a particular topic area. My emphasis on story has pointed out to me how out concepts of "truth" change over longer historical timelines, and has firmly taught me that science is an asymptotic journey rather than arrival at a destination. This really allows me to place my own work in a broader context.

It has also provided a way for me to step out of the box and examine the broader concept of "truth". The history of science is littered with examples of how really smart people reached some very questionable conclusions, both scientifically as well as ethically. As principle investigators on grants, because of the competitive nature of science we are often pressured to present ourselves as impervious authorities. But working on the comics has allowed me the freedom and mental space to push back and question myself, and my own biases. Why do I believe what I do, and how safe are my assumptions that support my beliefs? I think as a result of our work I ask better questions, and most importantly, respect the process when the answer I obtain from an experiment runs counter to my own notion of how it should come out.

Collaborations among scientists and artists inevitably challenge biases about ethics and aesthetics, in addition to inspiring debate about big questions such as the natures of truth and beauty. A geologist notes a debate with his long-time friend and collaborator, an architect with whom he has discovered fossils hundreds of millions years old. They bring the architect's 3D software modeling tools into the scientist's realm. They also work with X-ray imaging to reveal thin layers of sediment in ground rock. They have an ongoing debate what is "data" and how to present it. Nevertheless, their overlapping interests in visualizing and interpreting data have led to new ways of presenting geological discoveries.

A biologist collaborating with software modeling experts, in areas of medical imaging as well as visual arts, has experienced greater tension when working with another genre of composite images. These images are based on data from computed tomography (CT) scans, showing bones in a moving animal. To visualize the bones moving in context, the modelers reconstruct the data as computer graphics and then layer and synchronize it with video footage of the moving form. Where there are gaps in the skeletal data, the animator is willing to "fudge" some of the correlations and movements. The biologist takes exception to this practice. He would prefer to wait for more comprehensive and resolute functionality in the technology, or accept apparent glitches in imagery resulting from available technology. For the animator, an aesthetic of continuity related to believability prevails; for the biologist, an ethic evolves from integral representation only of the recorded data. He is willing to look beyond what is literally on the screen to implications of the data and finds beauty in both the image and the knowledge it relates.

The geologist also reflects on the adage among scientists about knowing when to give up. That's what he did after repeated attempts to discern shapes in X-ray images slicing through

unimaginably old rocks. The spectral forms were the same density as the surrounding material, so didn't show up well. The collaborating architect "harassed" him for more than a year to stay with the project, until they realized that the two-dimensional images they had amassed could be combined as layers in a 3D software model. This composite image enabled further study of what turned out to be oldest animal fossil ever found. Without the benefit of the new perspective, the scientist would have abandoned the effort and the discovery would not have happened. He notes that, often, the biggest leaps and bounds are made by people outside of a given field.

This geologist and architect are now engaged in a debate stemming from their differing impulses for moving the work forward. The geologist wants to continue using the grinding and imaging method they developed to find more fossils, but the architect wants to adapt a new workflow for a machine that could be useful in many fields. They have a provisional patent on the grinder and will soon submit an application for the full patent, which would enable placement of the device at museums and oil companies, and enable making a range of new artworks. Although the collaborators have different visions for the same things, these differences lead to productive discussion rather than conflict.

Not surprisingly, a strong message throughout the interviews is that a main benefit for scientists collaborating with artists is to support communication and education – with students and colleagues, and especially among the general public. Not only visualizations, but metaphors are powerful means of communicating complex information and sustaining people's interest in the work presented. Well executed, these modes can give scientific topics more immediacy, making them vivid in the minds of audiences.

A neuroscientist observes, "Considering artistic explorations can ... provide a needed balance to the analytic tendencies of the scientific endeavor, prompting it to redeploy onto the kinds of integrative issues that really make a difference in people's lives." Another neuroscientist notes that participating in development of broad communications can be an effective way to "give back," emphasizing that much research is funded by tax dollars. Popular renditions can also serve a recruiting function: the astrophysicist notes people entering her scientific profession having been fascinated by imagery that communicated processes and results.

Some of the respondents comment on similarities between artistic and scientific endeavors, the entomologist stating: "I don't see a deep distinction between the process of science inquiry in the laboratory and the experimentation and research done by artists as they develop an idea."

Several respondents speak to the importance and the pleasure of working closely, in frequent and tight communication, rather than through periodic hand-offs as the work proceeds. They speak repeatedly to the importance of working as a team. A data visualizer notes that problems emerge when the group does not work together continuously: if a scientist delivers data but does not engage the translation process, mappings will turn out to be wrong.

She also stresses the importance of having "hybrids" on the team, with grounding in relevant artistic and scientific areas but also computational mathematics and programming. Diversity of backgrounds is important as well, on the principle that the creative team forms a community working closely and learning about one another's various areas of expertise. A well-tuned group

can best manage another important aspect of the collaborative process, of figuring out what to include and what to leave out of a given realization.

The communications scientist also speaks to the need for close dialog among disciplines, but gives it a different spin by focusing on edification of the individual more so than cultivating a team process. He particularly likes when collaborating artists begin to learn about computers and other technology, and thinks that in the best cases they become their own programmers. He believes the best results emerge when the whole creative process is "in one head," with one coherent set of cultural values and personal attitudes driving it. He believes this is not an inordinate expectation, noting that architects and product designers typically learn technical skills along with creative. However, he does not further observe that these professionals typically situate their work in larger-scale production processes that require teams to interpret and realize the creative vision.

Many of the scientists report having experienced changes in their methods, priorities, focuses, or ways of conceptualizing, with some of the interviews suggesting resultant potentials for improving human lives. A neuroscientist describes recent development and affirmation of a drawing-based technique that activates brain plasticity in ways that could help rehabilitation of blindness and low vision. The geologist and architect are experimenting with ground-penetrating radar that can detect mass graves. This approach could move consideration of human rights violations from a solely historical perspective relying on written documents, to inclusion of studies of the environment.

Other respondents also note how their interdisciplinary collaborations have led to new areas of interest with potentials to benefit studies in psychology, medicine, and education. They speak especially to benefits in education, as do many authors of other SEAD White Papers. There is a growing body of work showing how arts can transform teaching and learning in traditional STEM fields.

A neuroscientist describes his fascination with 3D perception and curiosity about how art works could become tools for studying human perception of higher spatial dimensions. His preoccupation is echoed in the communications scientist's sense of the significance of his own imaging work:

> The main questions here, old as art itself, are: Can these images help you to experience in a new way the things and people pursuits alluded to? Why do you see what you think you see, and more than is in fact really there? How is it that crude or oddly structured pictures can be more evocative than scrupulously detailed, explicit ones?[2]

Summary

Collectively, our broader-reaching scientists pose a challenge to the modus operandi of cultivating deeper and deeper disciplinary knowledge at the expense of understanding context

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2 Portrait of the Artist as a Young Scientist. YLEM Journal, Jan/Feb 2005, 25:2.

and breadth of implication. A cognitive neuroscientist may capture this challenge best, by quoting Leonardo da Vinci:

> Principles for the Development of a Complete Mind: Study the science of art. Study the art of science. Develop your senses - especially learn how to see. Realize that everything connects to everything else.[3]

We conclude with Suggested Actions toward developing needed connections in contemporary approaches to thinking, learning, and creative productivity.

SUGGESTED ACTIONS

FOR INDUSTRY

• Sponsor local forums for mixing of people in business, academic, and nonprofit organizations, who are interested in creative process and innovative tools and methods.

• Support creation of public events and large-scale displays that invite participation by community members and require different kinds of skills to realize and operate.

• Sponsor scholarships and fellowships for students and faculty working in interdisciplinary fields.

• Join academic and community organizations in developing programs for people all ages, which communicate results of scientific research and involve community members in creative activities reflecting scientific knowledge.

FOR FOUNDATIONS, GOVERNMENT AGENCIES, AND OTHER FUNDERS

• Create new programs to support broadly interdisciplinary work.

• Encourage artists, as well as scientists and engineers, to collaborate on submissions to traditional programs.

• Use public receptivity to scientific topics as a gauge for increasing funds for scientific research.

• Make funds available to encourage academic, industry, and community organizations in developing programs for people all ages, which communicate results of scientific research and involve community members in creative activities reflecting scientific knowledge.

• Sponsor artist-in-residence and scientist-in-residence programs.

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3 National Science Foundation. Final Workshop Report: Art, Creativity and Learning. June 11-13, 2008.

• Provide support for technical assistance, as much as for lead investigators and students.

• Support publication and dissemination of books and other media explaining scientific phenomena for children (of all ages).

FOR EDUCATORS AND ACADEMIC ADMINISTRATORS

• Reformulate tenure and promotion policies to encourage interdisciplinary work.

• Reformulate IP policies to enable project-by-project combinations of patent and copyright and easy sharing of ownership across departments and institutions.

• Reduce the time and paperwork required for ethics certification.

• Facilitate scheduling of courses offered simultaneously across departments.

• Develop ways grant credit for courses offered in multiple programs across departments.

• Require enrollment commensurate with a single course, rather than counting an interdisciplinary course doubly.

• Equalize compensation for faculty teaching in interdisciplinary programs.

• Encourage joint appointments in art and science departments.

• Institutionalize encouragements for sustained, long-term interdisciplinary partnerships rather than ad hoc, one-off collaborations.

• Create funded opportunities for students to work on interdisciplinary projects.

• Support artist-in-residence and scientist-in-residence programs.

• Create new academic programs to develop creative practitioners who are able to produce interdisciplinary work of quality and depth on their own.

• Facilitate team development, focusing on the creation of the ensemble as the base unit in performance groups. This kind of recognition and support for the challenges in creating collaborations would benefit many whether the collaboration is among scientists or scientists and artists.

• Join industry and community organizations in developing programs for people all ages, which communicate results of scientific research and involve community members in creative activities reflecting scientific knowledge.

• Encourage facilities resource-sharing with organizations in the surrounding community.

Appendix: Interview Questions

What is your scientific discipline?

What is your art form?

Do you combine any other scientific or engineering perspectives in your work?

When did you start involving artists and/or designers in your work?

What motivated you to do so?

How would you characterize the nature of the artistic contributions?

To what extent do the results facilitate:
breakthroughs in your understanding of the scientific problem;
new formulations of older paradigms;
new experimental approaches;
communication of your work to colleagues;
communication of your work to the general public;
public engagement with your work;
education of your students and colleagues;
education of the general public;
the scientific inquiry itself.

Do you have favorite results from your collaborations with artists/designers?

What has worked best in these collaborations?

Why do you think it worked well?

What problems have emerged?

What caused these problems to emerge?

Are there ways in which your institution facilitated or hampered your collaboration?

What new opportunities exist to be promoted?

Have any patents resulted from your art-oriented projects?

Which results of the collaborative involvements most fundamentally changed your thinking about your science?

How has the involvement influenced your working method or approach in any way?

Has the work led you to inquiry of any other scientific problems or topics?

Any other thoughts about your art/science work?

Gender and STEM: No Shift Required

Coordinator: Deborah Tatar

Overview

In the past thirty years, several waves of opportunity have come successively closer to realizing Papert's vision of a world in which children can self-actualize as owners and creators of technology. Each wave, starting with Logo, has had strengths and limitations and while some have had considerable reach (FIRST Lego League, for example), none have as of yet become fixtures of childhood. Now, part of the opportunity that comes with a switch from a STEM to a SEAD perspective is the chance to build foundations for female---and more widespread male---participation in computing on a wide, humane platform in which the outside world is involving, inviting and discovering rather than persuading, cajoling and selling. In particular, recent tools associated with the Maker or DIY ("Do It Yourself") movement have the potential to increase embodied, craft-oriented, performance-focused behavior. Girls (and a range of boys) can now create inexpensive personalized objects that cause them to rub elbows with technology and technological thinking without having to first (or ever) label themselves as one of "them," the kind of person that actually likes technology. They can tinker, both with creations and identity. They can develop skills that will help them no matter what they go on to do, and their relationship to those skills can change over time. The crucial opportunity, ironically, lies in the relative unimportance of the technology in defining the students' projects.

The Sewable Computing Opportunity

Although tools such as Leah Buechley's sewable electronic components ([4];http://web.media.mit.edu/~leah/) are new, the opportunities they present resonate with older successes. They have social and technological properties that have been to some extent lost with the rise of internet-based computing. Additionally, the world of young people has traditionally included legitimate peripheral participation in activities that could be pursued in a more sophisticated fashion by adults. We are interested in children's relationships to sewable computing, but these activities are compelling for adults in a way that Logo, for example, never was and was never thought to be [13].

Sewable electronic components consist of a familiar selection of sensors, actuators, and power components that can be sewn like buttons, snaps, or trim using conductive thread (https://www.sparkfun.com/categories/135). LED lights, buzzers, buttons, toggle switches, light and motion sensors, batteries and the board are all equipped with eyelets (grommets) that serve the double function of allowing them to be attached to material and act as elements in a circuit.

Sewable computing is only one aspect of the larger Maker or DIY movement. But sewable electronic components are particularly exciting when we think about women, when we think about digital divide issues, and when we think about STEM careers.

Women and Sewable Computing

A number of factors make sewable computing a likely venue for becoming fixtures of childhood. The activities can themselves be social, just as knitting and quilting are often social acts. With even modest mastery, outcomes can be a personal expression on the part of the maker. They can be worn. Most importantly, they can be given. Gift giving is a foundation of civilization. Gifts do not have to attain perfection or win competitions to be valuable.

Sewable computing activity can spread easily. After attending a 2-hour sewable electronics workshop, I organized a novel 1-hour sewable computing activity for 95 local 7th grade girls during Virginia Tech's 15th Annual Women in Computing Day. Scaffolded by Computer Science volunteers, the girls sewed a simple circuit with a battery, button-switch and LED onto felt bangles, which were then further decorated with beads and embroidery thread. There were audible sighs of disappointment when the end of the activity was announced. We had to pry the groups out of the room (even with the materials to continue at home). The activity involved a great deal of volunteer effort, but less than $12/student in materials.

Figure 1: 7th Grade girls and Virginia Tech students use sewable electronics at the Association for Women in Computing's 15th Annual Women in Computing Day, April 2012.

Pragmatic Access

Sewable electronic components permit many levels of participation in handicraft. The thresholds, in particular, are very low. While some adult encouragement and guidance is required, the initial level is more comparable to that required for lanyard-making, knitting or embroidery than most interactions with electronics. The physical dexterity to sew with large needles and thick thread is in most cases attained by early elementary age.

Projects of moderate complexity can be funded with the kind of money "tweens" earn babysitting: LEDs, switches, and buttons are $1-$2; the conductive thread is about $.26/yard; a battery case is about $5. A project can involve parallel and series circuits and remain under $20 including the cost of an inexpensive garment. A consideration is that, while the individual components are light in weight, the decorated garment has to be sturdy enough so that it will not stretch too much. Stretching depends on both material and weave. The lightest weight--and least expensive--t-shirts are poor candidates. But the components are washable.

Participation may be possible through informal mechanisms including after-school clubs, libraries, Boys and Girl's Clubs, Girl Scouts, camps, community centers, homes, and through more formal academic middle or high school classes, such as vocational training, art or computer science.

All this is good. However, taken as a whole, cost becomes more difficult. At $22, the actual computer boards are expensive. And projects can become quite expensive indeed if the electronics are very elaborate or if the cost of the decorated item (shirt, scarf, jacket) is high. Furthermore, programming the boards requires access to a computer. However, projects do not require ownership, just access. Finished products stand alone.

Tying Sewable Electronics to STEM

Sewable components provide a practical, general, inexpensive opportunity for engagement with a wide range of creative activities, easily and comfortably organized, with low monetary or knowledge thresholds for participation and high potential for deep-seated widespread involvement. The creative opportunity can be situated within a wide range of extant formal and informal settings.

But there is also STEM learning potential. Even the simplest sewable computing project has systematic elements. The simplest projects still must involve sewing a circuit. As long as students are sewing circuits, they are engaging with an intrinsic, embodied connection to the physics of electricity and electronics. Circuitry, resistance, power, and signal degradation all come with the territory. Solving problems is a core scientific activity.

One focused STEM opportunity is to encourage girls to pursue computer science, a field that is markedly lower in female and minority participation than most. There are two aspects to this: 1) create learning pathways 2) do not mess it up.

1) Create Learning Pathways
At a certain point, we hope the students' imaginations will become too complex to accomplish their projects simply by sewing. They will want to use the computer. In this scenario, their first encounters with the programming interface will be driven by their image of what they would like to accomplish. The drives---gift giving, adornment, curiosity, self-expression, sociality---to create particular special items will motivate learning and exploration.

One challenge is to make those first encounters intriguing in the way of Logo: no threshold, no ceiling. Right now, several computer interfaces work with sewable computing components. One lovely interface builds on a Scratch approach to teaching children to program, using visual building blocks ([2], Fig. 2). However, even more focused environments are needed that explicitly scaffold movement from physical representations to digital ones and then scaffold movement into more sophisticated programming efforts. The issues here are not only teaching how the computer operates, but awakening the question of why. Why are some important elements (LED's) represented in the program, but others (conductive thread) not?
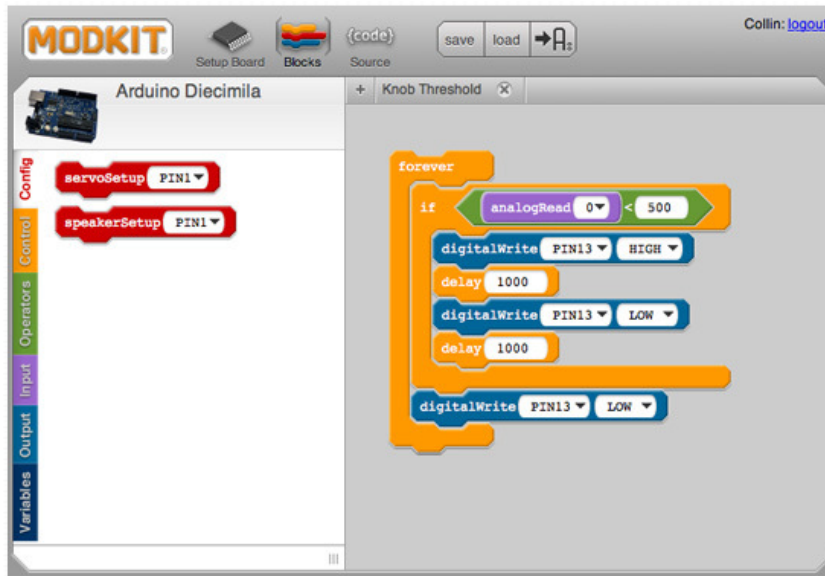
Figure 2: Scratch-like interface to Arduino programming, developed by ModKit [2].

2). Don't Mess It Up

The potential exists and is exciting. But the opportunity can easily be lost or preserved only for the most privileged. There are three primary ways to curtail it with the best of intentions: over-meddling, over-marketing, and over-measuring.

i. Over-meddling

Over-meddling is putting undue focus on the novel elements in the situation, on what we believe that we are changing, and insufficient emphasis on the relationship between old and new elements that allows the new to succeed. For example, suppose that we want to create sewable computing clubs for women. The temptation is to focus on understanding the sewable computing components and related activities. But the transformative success of the endeavor rests every bit as much on creating or finding the settings and understanding how they work with our new activities.

From a personal perspective, the steps to take to encourage women's participation can seem very simple and direct, "show them what it is". Yet, unhappily, the history of direct efforts to create positive social change is strewn with disappointment.

The great social psychologist Kurt Lewin, and his students left us with two ground rules that we would be wise to remember [8, 9].

The first is that the situation that you go into has its own strengths. It is far easier to undermine the strengths of the current situation than it is to build comparably strong new ones. Thus, all the resources that were poured into the Cambridge-Somerville experiment failed to compensate for the ways that those resources undermined the role of local groups and churches in providing support [8, p. 189]. It is for this reason that the mantra that we today in public discourse that the public school system in America today "could not be worse" is so very destructive. It is a light

claim to make that shows a frightening lack of imagination and ignorance of history. To become a fixture of childhood, sewable computing must be pursued in small, locally sensible steps.

A second key concept is that certain highly influential components of a social system (called channel factors) may appear insignificant from the outside. This concept is embodied in the power of the turtle at the bottom of the stack in Dr. Suess' Yertle the Turtle, or canonized in the idea of the pebble that diverts the stream.   In my own work with the large-scale investigation of a highly successful mathematics intervention that involved technology [14], a curriculum that featured soccer examples was a big hit with the white and Hispanic populations of Texas. But, forewarned, we knew that urban African-American children would need a different context. Getting the examples right was not a sufficient condition for success, but it was a necessary one.

One opportunity with sewable components is best explained by contrast. FIRST Lego League builds on the pre-existing popularity and familiarity of Legos and a certain way of engaging with Legos practiced primarily by young boys. The movement into the institutional structure of a league depends on the congruence of that kind of play and the movement of children at a certain age from free play into rule-bound, team-oriented activities that often involve competition and reward.   This works well. There are lots of benefits to participation and many girls like it too.

But there are also many people and communities who do not like to participate in such structured, team-based, goal-oriented activities and who reject overt competition.   I have sometimes written about acompetitive activities, such as jump-roping [16]. Jump roping can be pursued in a competitive way or a non-competitive way. But the difference is in the player not the game. Very often, and with good reason, some men and many women prefer to show their competence in the form of helping behavior. CompuGirls ([15], http://sst.clas.asu.edu/about/compugirls) builds on the particular strength of this value in Native American communities.

Rather than (or in addition to) giving people external rewards, we need to create or find the sewable computing equivalent of this situation. Busy hands, individual projects and talk can be very fulfilling without the need for a permanent institutional superstructure. Rather than aggrandizing the team or the institution, gift-giving is about the thought and the relationship. Adornment is about pleasure.

The hope would be that, if we can refrain from over-meddling by building on existing structures or creating ones with emotional resonance, we can use human sociality to educate a wide enough range of people to allow sewable computing to become a fixture of childhood.

ii. Over-marketing
"One lie undoes a thousand truths"---East African Proverb
We start from the idea that we would like more women to engage in STEM fields. Why? Some reasons have to do with the women themselves. It seems to modern American society wrong or unfair if women do not participate in equal numbers in elite vocations. Other reasons have to do with a perception of the benefits of involving women in STEM activities. For example, NCWIT promotes on its brochures research showing that mixed-gender teams work better than single-gender teams. The idea is that women should be involved in computing because they are needed.

Notice that, in a brute force way, the desire to involve women equally stems from the belief that girls are essentially the same as boys, while the desire to persuade them that they are needed entails the idea that women are somehow essentially different, that a women's perspective is a special contribution. So what are women, and why are they wanted? This is very confusing, even if one considers women as a coherent group. It is even more confusing if one considers the range of women and girls, their hopes, dreams, and prospects. It is yet more confusing when one considers the range of high-school, college and work-place environments that they might encounter. The situation is confusing.

Over-marketing describes a complex of persuasive behaviors that can be seen as producing a desired outcome. We want women to go into STEM fields, and so we try to persuade them using the tools at hand. This is deeply problematic for two reasons. First, programs based on simple persuasive tactics are vulnerable to several kinds of deceit and, second, such programs may engage in practices that undermine existing interest.

The epistemic basis for work on persuasion is the question of how people end up doing things that they would not otherwise want to do (for example, Asch's classic line length study [1], the Milgram's shock experiment [11] and the Stanford Prison Experiment [17]). These concerns overlapped with and migrated into the sales and advertising techniques that surround us, nicely summarized in Cialdini [5].

But pursuing gender and ethnic diversity in STEM fields is not the same project as persuading people to buy a car. We must ask ourselves whether we care about the sheep or the shearing. We know that we can get people to do things that make them deeply unhappy. I like to presume that, fundamentally, we don't want to do that. A better plan is to find or develop precisely those women or minorities that could be genuinely engaged with STEM fields, and that might not otherwise consider STEM fields. For one thing, there is no particular reason to believe that the women that might succumb to an offer made with the right persuasive overlay will be the women that most likely to prosper in STEM fields.

We should learn from one of the most successful educational enterprises of all: the enterprise whereby middle class (white) toddlers learn to love reading by being read to. The child appreciates the ball-of-wax in which s/he is held, talked with, and entertained with world knowledge and pictures. They learn that we value reading (and lots of other things) because it is what we do with them. Unless some other problem intervenes (dyslexia, for example), the child that has been read to walks into school ready to learn to read.

Part of the significance of DIY movement is that it is interesting enough for us to do, and for us to do with them, without reference to the future we hope for. Furthermore, the truth of the child's experience with sewable components does not put us in the position of over reaching. When we seek to persuade, we are liable to offer too much, substituting extrinsic motivation for more powerful and enduring intrinsic motivation [8]. And sometimes in our efforts to persuade, we lie. We lead women to believe that they will be valued and treated well in situations that are not set up to value them. We are tempted to deny that STEM fields are difficult. But they can be quite difficult intellectually, emotionally, and pragmatically. At their best, the work is absorbing

and challenging, just as medicine and many other worthwhile endeavors. Difficulty, seen through this perspective, may even be a selling point for people who are inclined to love an area.

The most reliable way to avoid over-marketing is to focus not on persuasion but on voluntary involvement and pleasure. Papert's vision of the child as bricoleur, or tinkerer, in the domain of computing is one of the child finding order and playing with it [13]. Systematicity and patterning have pleasures and attractions for many people outside their formal treatment in mathematics and science. Although, eventually, all computer scientists have to learn system properties, understand formal languages and engage in top-down thinking, their discovery of top-down thinking may arise from bottom-up, embodied exploration.

iii. Over-measuring

Over-measuring is utilizing the forms of quantitative experimentation and inferential statistics without a sufficiently firm grasp of the phenomena and circumstances being measured. We provide limited resources to support the promotion of STEM careers, and even more limited resources to support arts or crafts. Naturally, funders want to know whether their investments are worthwhile. So too do the researchers who are spending their lives in well-meant endeavors. But the simple question, "can we create fun, nurturing environments for girls in which they are exposed to electronics and computer science?", is self-evident. Of course we can, with enough money and good will. The harder questions---whether providing such circumstances and whether particulars of such circumstances lead more women to choose STEM careers---are part of complex epidemiological problems. We know something about indicators, but all sewable computing or any program can really do is invite participation, not determine it. And these issues do not really need measurement, just documentation.

When thinking about particular questions, such as whether women exposed to sewable computation will go into Computer Science, it is important to remember the scale of change involved; we would have a lot of female computer science majors at Virginia Tech if .1% of the graduating seniors from public schools in Virginia enrolled in the program, as opposed to the .016% that actually do. To detect this scale of change against noise is, at best, extraordinarily difficult and expensive. To compare the goodness of one program against the goodness of another is impossible.

Unhappily, we can mess up the project of sewable computing by over measuring.   The demand to measure is not neutral. The terms of the measurement become the terms of concern in describing the situation, especially in poor or needy circumstances. They push researchers and practitioners towards over meddling and over marketing. They may encourage adults to push girls too quickly or too hard towards the technology, turning that into a power struggle rather than an invitation.

In all cases, we must think, as a society, about what is most important to us and how we intend to get there. Perhaps less emphasis on measurement would risk some waste. However, it might also allow a more sophisticated descriptive phenomenology to arise and contribute to participation by the neediest young women.

Suggested Actions

Goal: To promote sewable computing knowledge and practices in a way that will allow them to become fixtures of childhood, and thereby to lay the groundwork for increased mastery of STEM skills and increased participation in electrical engineering and computer science professions for women.

Approach: Pursue a variety of deliberately distributed activities that support widespread local ownership of sufficient knowledge and development of local taste cultures and communities.

Stakeholders: Funders interested in increased involvement by women in STEM careers. These include NSF, CSTA, CRA-W, ISTE, and NCWIT. Google and Microsoft have been known to fund education work with a CS focus. The High-Low Tech lab at MIT, which derives an income from the sale of sewable computing items, may also have an interest.

Roadblocks:
i.   accessing the people who might become part of an enduring community.
ii. helping implementers refrain from seeing the "real" purposes of sewable computing activities as teaching STEM.
iii. developing and deploying sufficiently simple, fine-tuned computing environments and materials.

New Opportunities:
1) Provide seed money for many small sewable computing efforts, housed in a variety of public and private spaces. Think of this as loosely analogous to micro-financing. Training and materials will be made available to individuals or small groups with passion and local knowledge. They will not pay back the money, but instead undertake to pass along their learning to the communities they strengthen and create. Gather low-stakes, phenomenological reports.

2) Training through cascading, small, inexpensive workshops. One starting place would be workshops attached to conferences that highly trained people will already be attending, such as AERA, sigCSE, IDC and the Grace Hopper Celebration of Women in Computing.

3) Create even simpler computing environments, more focused on the electronic underpinnings, for the transition into computing.

4) Create and build upon existing simple resources that teach about electronics and problem solving in electronics (such as resistance, capacitance, properties of the thread). Leah Beuchley's group has a number of tutorials (http://hlt.media.mit.edu/?p=1283). These are, however, oriented towards a lovely but specific taste culture, and a relatively high capacity to learn through written instruction.

5) Create one or more simple inexpensive, low-production value magazines for students to publish the projects, modeled on the Lego magazine and possibly partner with Beuchley's group at MIT or Scholastic. Content will consist of new technological items, pictures of kids

with their creations, plans for designs and computer programs. (Maker magazine serves an older, richer, up-market population; Lilypond (http://lilypond.media.mit.edu/) is more polished and assumes a high degree of internet connectivity.)

6) In all of the endeavors, the first effort should be to support existing local taste cultures. Latina girls in Texas do not necessarily care about the same kinds of projects as New YoRicans.

Goal: develop a better phenomenology of how women enter into STEM careers, especially computer science. Utilize epidemiological as well as qualitative modeling. Conduct longitudinal research on the development of interest in STEM careers.

Acknowledgements

References

[1] Asch, S. (1955) Opinions and Social Pressures, Scientific American 11:32.
[2] Baafi, M. (2012) Drag-and-Drop Arduino Programming, MAKE, 25 p. 52
[3] Bransford, J. and Schwartz, D. (1998) Rethinking Transfer: A simple proposal with multiple implications. Review of Research in Education (24) p. 61-100.
[4] Buechley, L. and Perner-Wilson, H. 2013. Crafting Technology: Reimagining the Processes, Materials, and Cultures of Electronics, Forthcoming in the Journal ACM Transactions on Computer-Human Interacation (ToCHI).
[5] Cialdini, R. (2006) Influence: the Science of Persuasion. New York: Harper Collins.
[6] Jepson, B. (2010) Modkit: a graphical programming environment for Arduino, MAKE, Retrieved from: http://blog.makezine.com/2010/09/24/modkit-a-graphical-programming-en/ on November 2, 2012
[7] Kutznetsov , S., Trutoiu, L., Kute, C., Howley, I., Siewiorek, D. & Paulos, E. (2011) Breaking Boundaries: Mentoring with Wearable Computing. CHI 2011, p. 2957-2966.
[8] Lepper, M. R., Greene, D. and Nisbett, R. E. Undermining children's intrinsic interest with extrinsic rewards: A test of the overjustification hypothesis. Journal of Personality and Social Psychology, 28 (1973), 129-137.
[9] Lewin, K. Field theory in social science; selected theoretical papers. Harper and Row, City, 1951.

[10] Lovell, E. Getting Hands On with Soft Circuits: A Facilitator's Guide. Retrieved from: http://lilypond.media.mit.edu/ November 2, 2012.

[11] Milgram, S. (1974) Obedience to Authority: An experimental view. New York: Harper Collins.

[12] Nisbett, R. and Ross, L. (1991) The Person and the Situation. In (T. Nadelhoffer, E. Nahmias, & S. Nichols, Eds.) Moral Psychology: Historical and Contemporary Readings. Malden MA: Wiley-Blackwell.

[13] Papert, S. Mindstorms: Children, Computers and Powerful Ideas. Basic Books, New York, 1980.

[14] Roschelle, J., Tatar, D., Shechtman, N., Knudsen, J. (2008) The role of scaling up research in designing for and evaluating robustness. Educational Studies in Mathematics, Special Issue on Democratizing Access to Mathematics through Technology: Issues of Design, Theory and Implementation— In Memory of James Kaput (S. Hegedus and R. Lesh, Eds.). 68(2), p. 149-170.

[15] Scott, K., Aist, G. & Hood, D. W. (2009) CompuGirls: Designing a Culturally Relevant Technology Program, Educational Technology, v49 n6 p34-39 Nov-Dec 2009

[16] Tatar, D., Lin, S. and Lee, J.S. Playground Games and the Dissemination of Control in Computing and Learning (2008). In (DiGiano, C., Goldman, S. & Chorost, M., Eds.) Educating Learning Technology Designers. Mahwah, New Jersey: Lawrence Erlbaum Associates. p. 230-257

[17] Zimbardo P. (1973) On the Ethics of Intervention in Human Psychological Research: with special reference to the Stanford Prison Experiment. Cognition 2(2), 243-256.

Creations of Many Minds: Contextualizing Intellectual Property Issues Arising from Collaborations across the Disciplines of Science, Engineering, Arts, and Design

http://wp.me/P2oVig-o9

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Abstract: Navigating intellectual property (IP) rights in collaborations across sciences, engineering, arts, and design can be a complex endeavor for all concerned. Highlighting new and adapted historic forms of media, this white paper draws on existing literature, original case studies, and interviews to speak about cross-disciplinary collaborations in which intellectual property (IP) might pose obstacles and opportunities and have an impact on creative forms. It calls for flexibility, trust, and respect for the wide range of views held about IP, sensitivity to the varied knowledge and practical experience that collaborators in diverse disciplines might possess, and an openness to learn from and teach one another. Lastly, it encourages critical perspectives and suggests practical actions by specific stakeholders and wielders of influence to foster positive results.

Keywords: Cross-disciplinary, collaboration, authorship, intellectual property, science, art, media, amateur, professional, trust.

Introduction

Because IP in cross-disciplinary collaborations is an unstable factor that is interwoven into the participants' shifting contexts, disciplinary knowledge, and professional relationships, it can be of significant consequence. Such collaborations take place not only between a wide range of disciplines (the focus here is on sciences, engineering, arts, and design, with attention given to comparison and contrast with amateur and professional statuses), but also in many different situations and in a variety of structures, including academic frameworks, designated cultural programs, organizations that facilitate residencies within industry, and self-organized projects.[1] Some collaborators may have multiple roles and affiliations tied to policies that could dictate that other parties---employers or sponsors---have a stake in IP that might emerge from independently initiated collaborations. In this paper we address these issues through four detailed case studies.

Along these lines, in addition to complex contexts, this white paper notes that the wide variety of collaborators' general knowledge of IP, especially in relation to cross-disciplinary collaborations, can also be a destabilizing element within these frequently experimental arrangements; this factor is influenced by collaborators' understanding of the ways in which IP is approached and regarded in their primary fields. However, in some cases, interviewees (also referred to here anonymously as "informants") had only very general ideas about and a vague interest in IP, even in their primary field, which could make potential fundamental decisions difficult to resolve if they arose. One scientist involved in a successful cross-disciplinary collaboration disarmingly stated, "I have to confess that I had never given a thought to intellectual property concerns in my collaboration" (pers. comm.), underscoring that IP rights do not necessarily have to be exercised

(Merges 2011, 84--86), and giving emphasis to the two case studies in this white paper that show they need not be an obstacle if approached reasonably.

However, the sources of IP conflict are also an uncertain component. In fact, two case studies in this white paper reveal obstacles and issues emanating from nonprimary collaborators, highlighting a seemingly less predictable external threat. Based on interviews, there also appears to be a particularly loose sense of IP in relation to publicity, news, and sharing, with potential exposure and recognition tending to encourage some to give over material for reproduction with little consideration of terms, while more care might be taken in terms of IP in other contexts. In addition, the fine print of agreements can sometimes elude authors, allowing for other unintended uses of their works.[2]

This white paper also focuses on the media used in these collaborations and the kinds of innovations that arise from them, and thus touches upon the perception of participants' credibility,[3] imagination, persuasion, and trust as based to some degree on values, both in their professional roles and as expressed in their intellectual properties.

Owing to the perceived sensitive nature of discussing IP obstacles within cross-disciplinary collaborations, some informants chose to remain anonymous in order not to disturb ongoing personal and professional relationships, among other reasons. Protecting anonymity required omitting some descriptions of the projects under discussion, which also masked some relevant information and concerns. One informant pointedly said that he had not shared everything, and many others we approached declined to participate altogether. While in some cases this was due to scheduling conflicts, it could also be a significant finding for a white paper aimed at identifying IP obstacles and opportunities in cross-disciplinary collaborations, because it serves as a reminder that IP concerns are frequently both confidential and ongoing, and further suggests a potential long-term effect for future considerations---that those who have negative experiences in cross-disciplinary collaborations might not disclose their obstacles and might not pursue these collaborations again, while those who have positive experiences might not disclose approaches that could otherwise serve as models to reduce obstacles and encourage successful cross-disciplinary collaborations.

It certainly suggests the need for more study, though we strongly suspect that the benefit of disclosing confidential information is less obvious than the benefit of protecting reputations and personal and professional relationships. Nevertheless, we have been able to include a number of bold disclosures, firsthand accounts, and evidence of productive outcomes.

In spite of scant non-Western examples and few comparisons and contrasts in the larger realm of international law and economics, we might urge consideration of an assertive exploratory curriculum that centralizes IP to inspire creativity (see Japan Patent Office, Asia-Pacific Industrial Property Center, and Japan Institute of Invention and Innovation 2008). While this is an intriguing approach, it could potentially raise questions about a balanced or neutral presentation of IP. An instruction guide in the US that is narrowly focused on ethics and references interdisciplinary collaboration might offer a point of contrast (Online Ethics Center for Engineering 2006).

This white paper is not intended to offer legal solutions to specific problems. Instead, it focuses primarily on four case studies and notes areas in which there are obstacles and opportunities in relation to IP in cross-disciplinary collaborations.

Background

The specific topic of IP issues arising from collaborations across the disciplines of sciences, engineering, arts, and design takes place against the backdrop of a larger discussion of IP as the conception of intangible properties. It has to do with both a focal point of concern about how IP functions in societies and a balancing act between rewarding creators and serving the public interest, set within a system of actions that are ever-changing. Four case studies are included here because there are numerous points of view published on the general topic of IP and a dearth of publications on the specific topic of IP in cross-disciplinary collaborations, and the case studies reveal specific subjective contextually based obstacles and opportunities. It is of interest that two of the collaborations are characterized as residencies (see note 1). While this small sample is by no means representative, it touches on key IP issues and reveals the various weights placed on IP in different contexts, while revealing a variety of knowledge and experiences.[4]

Case Studies: Cross-Disciplinary Collaborations and Intellectual Property

Case studies and interviews with participants in cross-disciplinary collaborations revealed both common concerns and unique situations in relation to IP, tracing a variety of situations in which IP was not always an impediment but was nevertheless a consistent, active consideration that subtly influenced the creative forms that emerged.

Case Study 1

A designer who collaborated with scientists in a relatively independent way in examining biological forms reported no unusual IP issues arising in the collaboration. This was true despite their having had neither formal discussion nor any agreement on IP in advance of the cross-disciplinary collaboration, and despite the fact that an invention emerged from the collaboration that attained provisional patent status, triggering a collaborating scientist's employer's IP policy, which contained a right of first refusal clause; the importance for one collaborator of maintaining first-authorship credit in science publications; and the different potential goals for their discoveries and invention the collaborators ultimately began to develop. The informant said he did not view these scenarios or key points as conflicts, but rather as "decisions to be made together,"[5] and that the relationship was based on "trust" and mutual support, adding, "It is all about relationships" (pers. comm.). When asked if he thought an initial written contract would have served a purpose, he answered, "A contract would have killed experimentation." He added, "At the beginning stages, a contract would have been confining and insidious" (pers. comm.).

Why were trust and experimentation in cross-disciplinary collaboration important for these collaborators to foster? These were some of the key elements that our informant viewed as enabling the work to thrive as "a successful collaboration that approached a common problem that could only be solved with tools---instruments and methodology---from different disciplines"

(pers. comm.). Velonaki et al. (2008, 12) have identified trust as among the characteristics that are essential to successful cross-disciplinary collaborations. Important contextual factors in this collaboration could include long-standing relationships among the parties, relatively equal amounts of control over the work, and very little external oversight. Further, existing mutual interest and appreciation for an aspect of the collaborators' nonprimary disciplines is frequently cited as an important element in positive cross-disciplinary collaborations (Weinberg 2011, 265--66; Blackwell and Jefferies 2006, 262). The presence or cultivation of these kinds of conditions could help avoid a variety of obstacles, including IP concerns, and aid in clearing the way for the development of new forms. In this case, the anonymous collaborators in the study are actively supporting one another's future goals with their discoveries, even though their directions have diverged.[6]

Case Study 2

In contrast to the previous case, an anonymous artist who had developed hardware and software for creative visual and sonic biofeedback systems sought and secured a residency as part of a cross-disciplinary collaboration with a medical doctor for the use of his technology in a clinical setting within the context of a children's hospital. This brought him into an institutional environment with many employees and patients, no deeply established personal or professional relationships, complex policies and unclear boundaries, and greater oversight, which were contrary to his creative practice of less-controlled experimentation and a more public idea of exhibition. He immediately faced many obstacles related to IP, artistic research methodology, and old-fashioned bureaucracy and workplace politics that were nevertheless unique to his status as an artist collaborating with a medical doctor, who was one among many other employees of sometimes competing authority and in a context of freewheeling policing of activity and varied interest in identifying and enforcing policies.

During the residency's first stages, a senior staff member in charge of biomedical engineering who was not a participant in the cross-disciplinary collaboration visited an interactive exhibition of the technology in a public area of the hospital that was used by the collaborators as a form of research to observe participants' responses to prototype designs and their abilities to influence the displays they were developing for biofeedback. Owing to his concern that the artist was using noncertified biomedical sensing technology, the staffer immediately took action to suspend the residency. According to the artist, "He made a complaint to the Research Committee and requested that we cease our research until we had obtained a clinical trial number, and provided evidence that our heart rate sensing technology was registered with the TGA [Therapeutic Goods Administration]" (pers. comm.). During a formal meeting with the artist and the staff from the Research Office to address the senior staff member's concerns, the staff member expressed surprise that the device was wireless and thus posed little or no risk. Drawing on historic stereotypes about limits on artisanal and scientific abilities (Jackson 2003), which Mandel calls for partly remedying by "establishing a new substantive standard for determining joint creatorship status in both patent and copyright law" (2010), the artist reported that the senior staff member also seemed surprised that he had engineered the wireless sensor system himself, remarking that such a design had potential IP value and offering to assist with the collaborative research. The artist turned down the request; the hardware issues were already resolved, and as

he pointed out, collaborative research at the hospital was not focused on developing biomedical engineering but on the use of biofeedback in clinical settings.

The senior staff member's attempt to put the artist into a more formalized framework within the hospital brought with it cumbersome challenges that indirectly led to an IP concern without sensitivity to the artist's knowledge---or lack thereof---of this context. The formal review identified a requirement that the artist must obtain public liability and professional indemnity insurance that was not available under his insurance policy through an art workers' organization. The costly new policy would exceed the project's budget, further delaying the residency. The collaborators' solution was to create a casual, part-time position at the hospital with the title of senior research manager, which would provide the required insurance coverage for the cross-disciplinary research and an hourly wage. However, one potential problem with becoming an employee of the hospital was a policy that any IP generated by hospital employees as part of their work there was by default the property of the hospital. To this end, as part of the job acceptance contract, the artist filed a declaration of IP in a disclosure of invention document to protect his existing IP and related discoveries while he used it in the collaborative research with the doctor.[7] This case demonstrates how complex IP concerns can rapidly become, and provides an example in which the need to address it within the larger context of the cross-disciplinary collaboration can be critical in removing obstacles in order to focus on the opportunities.

Case Study 3

A cross-disciplinary collaboration that presented few IP obstacles---in part because of institutional motivations that subtly encouraged collaboration---between the artist Guillaume Le Moine and the Leti Institute, a research and technology branch of the French CEA specializing in nanotechnologies and their applications, came about through a relationship between Le Moine and an acquaintance, a PhD student, who introduced him to the Leti Institute's team of scientists (Le Moine, pers. comm.). The cross-disciplinary collaboration appeared to be unusually informal and spontaneous in an otherwise highly formalized institution, but this ease reflected an existing institutional interest in promoting the relationship between science and art.[8] Prior to and after the collaboration there were no written agreements for any IP rights that might emerge from the collaboration: the only condition was a verbal agreement to acknowledge the Leti Institute and the CEA each time the artwork was shown, mentioned, or reproduced (Le Moine, pers. comm; Denis Renaud, expert in process integration, Leti Institute, pers. comm.).

The Leti Institute employed an electron beam used for alternative lithography to cut out and build microelectronic components, and Le Moine was interested in using this existing technique to execute a work of art. His artwork entitled Another World (2008) consists of a single sentence written at the nanolevel on a silicon disc and set in a circular metal frame (Le Moine 2012; Constancias 2008).[9] The sentence, which is invisible to the naked eye but legible under a microscope, conveys the idea of distance through perception and scale, as follows: "Another world is possible, it's here." This would theoretically have been easy to accomplish, because the scientist collaborators had already used the technology to define shapes at the nanoscale, but the artist challenged them by requesting that the sentence be written in a specific style and font. Le Moine has stated, "It was important that the font was in some ways equivalent to the one used for tags on real street walls, carrying this 'rebellion' dimension and relating to handwriting" (Le

Moine, pers. comm.). While the scientists already knew how to use a PDF file with a design model to program the ray of electrons and produce all kinds of simple shapes, to realize Le Moine's art they had to carefully adapt the data to manage a precise transformation of the font at the nanoscale and make sure the sentence remained legible, built with well-shaped letters.

While the cross-disciplinary collaboration appeared to be viewed not so much through a lens of IP as through the prism of cultural contribution, it did serve to bring the Leti Institute's endeavors to a larger public that could include potential industry partners and entrepreneurs, at the same time that it promoted the Leti Institute's IP (Renaud, pers. comm.). And although the Leti Institute does not at present see an application for specialized fonts in any further scientific pursuits (Renaud, pers. comm.)---which may still be an open question, as organizations potentially begin to see unique tags at the nanoscale as a valuable marker---it did foresee the value in the potential publicity that the project might generate, since part of its mission involves technology transfer (Le Moine, pers. comm.; Renaud, pers. comm.). Despite having no written IP agreement, the arrangement took the contractual form of a verbal agreement to credit the Leti Institute and the CEA's contribution to the work as a collaboration. This short-term cross-disciplinary collaborative opportunity presented itself by way of established relationships and an institutional awareness of the value of working with artists. A work in a relatively new medium was realized and specific IP and authorship concerns were addressed informally through mutual trust and respect among the collaborators.

Case Study 4

Different approaches to acknowledging authorship and credit can converge in relation to cross-disciplinary collaborations and cause conflicts in ways that may challenge participants' values and introduce stipulations that potentially limit creativity. In this case, the artist Daniela De Paulis collaborated with the sound specialist Jan van Muijlwijk, whose primary role in the collaboration was as a part of CAMRAS,[10] an amateur radio group that is organized as a foundation and had restored the Dwingeloo radio telescope, which is owned by ASTRON, the Netherlands Institute for Radio Astronomy. De Paulis proposed that together they find a way of using a historic radio communication technology called "Earth-Moon-Earth" (EME), commonly known as "moon bounce" (which CAMRAS was already using for a non-visual purpose) to send visual images to the moon and back to the earth. The EME technology was originally developed by the United States military after World War II as a way to relay communications signals by literally bouncing signals from the earth off the face of the moon and back to the earth.[11] Van Muijlwijk's concept for moon-bouncing an image was to utilize SSTV (slow-scan television) software, which is commonly used by radio amateurs to share images, to transmit and reconfigure images. Once they succeeded in doing so, the entire process was named "Visual Moonbounce." Because the technology involved already existed, it is not easy to discern the innovation, but as Van Muijlwijk explains, "Moon-bouncing SSTV is unique," adding, "We [CAMRAS] were the first radio amateurs who succeeded in moonbouncing a picture," and "that's only because there was not a dish big enough [previously] to create the necessary signal strength" (pers. comm.), demonstrating the significance of CAMRAS's restoration of the Dwingeloo dish and emphasizing the result (see De Paulis 2012).

As is customary with the group of radio amateurs, the images that were moon-bounced were shared among themselves. They could also request to have their own images moon-bounced by sending them via email to Van Muijlwijk (Van Muijlwijk, pers. comm.). Early into the collaboration, De Paulis noticed that images that had been moon-bounced were appearing in a variety of contexts without mentioning authorship credits for her and CAMRAS. De Paulis has stated that "a fellow radio amateur from the U.S." had begun using images in research-based presentations, published papers, self-promotion, and ways that suggested commercial applications, assigning authorship to himself with no additional credit to her and CAMRAS, and circulating the material with misleading attributions that could confuse the original research by De Paulis and Van Muijlwijk (De Paulis pers. comm.) [12] De Paulis has stated that this is "not usually what radio amateurs do" (De Paulis pers. comm.). While CAMRAS uses a variety of informal ways of consistently crediting works within the group (Van Muijlwijk, pers. comm.),[13] De Paulis was apparently used to more formal crediting practices, presumably based on her experience in the art world. Van Muijlwijk was not very familiar with formal crediting and the concept of IP was new in the relatively open culture of radio amateurs (Van Muijlwijk, pers. comm.), in which sharing is frequently part of participation. However, he recognized that there was no evidence of the informal credits used by radio amateurs (Van Muijlwijk, pers. comm.). This caused the collaborators to come together to arrive at a solution.[14] Blending the role of artist with her collaborators' roles, De Paulis reported that at the time she had also become part of CAMRAS (pers. comm.). This created an odd doubling effect of authorship by causing De Paulis to be both independently credited by name and also implicitly credited as part of CAMRAS, resulting in her occupying an unusual position of both first and second author, which can have different values aligned with the level of contribution, with alphabetical order being a minority structure in a general study (Marušić, Bošnjak, Jerončić 2011).

After failing to reach a friendly agreement with the radio amateur who was not crediting images that were moon-bounced, De Paulis and Van Muijlwijk sought legal advice from an artists' union in the Netherlands, who encouraged them to develop a credit policy (De Paulis, pers. comm.); the collaborators also reviewed practices of existing residency programs in which both the artist and the organization are credited for the research (De Paulis, pers. comm.). Ultimately, they agreed to formalize credits; the discussions took place on the "CAMRAS board level" with De Paulis and Van Muijlwijk (Van Muijlwijk, pers. comm.). According to De Paulis, "The credits issue was solved amongst Jan, ASTRON and I, most CAMRAS members don't know much about it" (pers. comm.).[15] She added, "We drafted a paper as a group, including myself---the artist---and the radio amateurs, where we agreed on several points. . . . Images moonbounced at the Dwingeloo radio telescope for an external party would need to be accompanied by the credits for both CAMRAS and the artist. Should the party refuse or ignore this request, no other images can be moonbounced for him/her" (pers. comm.). According to Van Muijlwijk, the specific credit terms apply to everyone (pers. comm.), not simply external parties. De Paulis characterizes the credit policy as based on Creative Commons principles (De Paulis, pers. comm.). The credit requirement also applied to parties "requesting research material concerning Visual Moonbounce" (De Paulis, pers. comm.), which is a common practice for reproducing material but atypical for solely personal research purposes in some fields. The agreement required that it be signed and returned (De Paulis, pers. comm.).[16] The promulgation of a formal credit policy for moon-bounced images among ASTRON, CAMRAS, De Paulis, and radio amateurs is distinct in that it exists parallel to the ongoing informal established norms for giving

credit among radio amateurs, and could be viewed as an expression of one aspect of the collaboration that brings both potential gains[17] and losses.[18]

The cross-disciplinary collaborative work, the concern for formal credit on the part of the artist, and the disappointment in a fellow radio amateur combined to raise interesting questions about the acknowledgement of authorship, which has ramifications in terms of IP rights. The radio amateur who used the images without credit broke the informal rule, ignored the new policy, and can no longer have access to the process. The solution to the problem he created raises the question of whether or not the newly forged crediting policies represent emerging norms of self-policing within a group (Oliar and Sprigman 2011) or suggest a less flexible approach that could hinder access to technical processes and scientific equipment. In this case, providing credit for access to an otherwise unprotected process could raise a substantial representative consideration in terms of IP, because there is said to be only one facility capable of producing high-quality, well-defined images that are moon-bounced (De Paulis, pers. comm.; Van Muijlwijk, pers. comm.). This kind of development is of interest for those pursuing cross-disciplinary collaborations because, in spite of the collaborators and their organizational associates' intentions,[18] it holds the potential of creating a kind of exclusive legal right by allowing access to only those who agree with a specific assignment of authorship for a process that combines common technologies with restored historic equipment; [20] it could also raise questions about the interests of creators and authors and public interests (Wyszomirski 2000, 4--6). In addition, it has the potential to impede broader experimentation with images that undergo a protected technical process, impair the ability to further develop results that could lead to new forms of creative expression, and place burdens on those researching the subject.[21] In the case of moon-bouncing images, the credit policy was formed and enacted in reaction to a significant, assertive threat that was external to the primary cross-disciplinary collaboration. De Paulis explains that the "policy we decided to apply to artistic and cultural content developed at Dwingeloo is a way to credit present and future contributors' research at the telescope. However, by no means should crediting interfere with further development of the technology in question or any future work carried out at the radio telescope. This policy is our initial attempt to avoid the same kind of time-consuming problems in the future. We keep sharing images with the public and usually a reasonable request for credits is welcome" (De Paulis, pers. comm.).

Summary

This white paper establishes IP as a consistent, active consideration that can influence and shape media and methodologies. Nevertheless, the case studies and interviews with cross-disciplinary collaborators in sciences, engineering, arts, and design demonstrate that many participants possess an uneven awareness and knowledge of IP rights and their implications in relationship to the forms they create. In this regard, educational materials on IP should be comprehensive and balanced. This white paper also shows that professional and personal relationships both across and within professional disciplines can increase opportunities for cross-disciplinary collaborations. In addition, trust, respect, mutual support, and goals that benefit each collaborator are conditions that can encourage positive results and can help to ameliorate IP concerns if they arise. In highly regulated conditions that lack clear values or strategies about cultivating cross-disciplinary collaboration, coherent discernible linkage to IP should be established so that opportunities for collaborations that could otherwise be mutually beneficial to the participants

and to the public interest are not missed or bungled. Further, sensitivity to different values and approaches to acknowledging authorship and credit and their implications in relation to cross-disciplinary collaborations are important considerations for avoiding obstacles and embracing learning and opportunities without limiting creativity. Since even independent cross-disciplinary collaborations take place in some kind of context, collaborators should be alert to threats and obstacles from nonprimary collaborators who might interfere with IP.

Lastly, this white paper acknowledges a paradox in making the suggestions below that are broadly about increasing knowledge and awareness of IP in a world seemingly oversaturated with IP considerations, where rights are being selectively exercised and enforced, and taking into account the fact that in some contexts established IP restrictions can potentially limit access to creative works and scientific instruments, leading to the negative effect of impeding contributions, experimentation, and research. A statement by the Smithsonian Institute's Office of Policy and Analysis, in the context of a report on interdisciplinary collaborations that is supplemented with a section that looks beyond traditional academic models, could be considered representative of an institutional view of this paradox: there is a challenge to find "innovative ways to exploit open source principles and at the same time minimize the risk of loss of intellectual property" (2010, C-7).

Suggested Actions

1. Obstacle: Uneven knowledge of IP rights among students, educators, professionals, and participants in cross-disciplinary collaborations in sciences, engineering, arts, and design.

Suggested Actions: We suggest that organizations that develop and assess educational programs, including accreditation bodies, take steps to encourage a more comprehensive approach to IP that takes into account the varying standards and practices of sciences, engineering, arts, and design.

We also suggest that international organizations and governments that provide educational materials about IP carefully consider the variety of goals of specific learners and the diverse concerns they might have through balanced presentations of the lawful protections of IP rights, the integration of broad and inclusive points of reference in relation to IP, and the neutral use of the subject of IP as an educational tool.

A further suggestion is the development of online resources that include a free tutorial on IP rights, perhaps modeled on the National Institutes of Health (NIH) Office of Extramural Research's Protecting Human Research Participants Course, which draws on historic and contemporary case studies to teach about risks in human-subject research and how to avoid them, and offers a certification at the end as proof of completion. The proposed course would teach about IP and how it relates to a wide range of pursuits in a variety of traditional and emerging contexts, including cross-disciplinary collaborations in sciences, engineering, arts, and design.

2. Obstacle: The general lack of professional and personal relationships across professional disciplines limits opportunities to initiate and participate in cross-disciplinary collaborations, relegating factors like IP concerns to a lower priority, which could trigger flashpoints of conflict

when collaborations do take place. (It is of interest to consider this obstacle in relation to the suggested actions in 4 below.)

Suggested Actions: Since personal relationships and mutual trust play an important role in successful collaborations, we suggest that scientists, engineers, artists, and designers increase opportunities for interactions between disciplines, and that individuals who are interested in cross-disciplinary collaborations make a concerted effort to enlarge and diversify their professional and personal networks to support their goals and begin to address specific issues such as IP concerns.

3. Obstacles: Just as artists and designers might not very often consider working with scientists or engineers, scientists and engineers can sometimes overlook opportunities for working with artists and designers. Science-based organizations can be unprepared to adequately accommodate such collaborations; when they are initiated, there can be both unnecessary conflicts related to misconceptions of artistic research methodology on the organizations' side and a lack of understanding of regulations, privacy, safety, and formal scientific protocols on the artists and designers' side. Likewise, many artists, designers, and related groups and institutions are typically not organized to accommodate scientists and engineers, and might not have established crediting policies and other ways to reward them.

Suggested Actions: We suggest that science-based organizations promote awareness of the potential benefits of working with artists and designers in cross-disciplinary collaborations. To support this, we suggest the development of human resources protocols that can help ensure success. These would include enhancing clarity regarding the sometimes intertwined issues of IP, health and indemnity insurance, public-relations benefits, and implementation of cross-disciplinary training for all collaborators to encourage mutual understanding, respect, and successful outcomes. Likewise, artists, designers, and related groups and institutions would be wise to consider their abilities to accommodate scientists and engineers, and what form that would take in practical terms and in relation to IP considerations, particularly with regard to ensuring that scientists and engineers are consistently and properly credited for their contributions and taking into account how the circumstances of these collaborations impact authorship credit and rewards.

4. Obstacles: A conflict between protection and encouragement of developing IP can arise as a result of increased awareness of academic honesty in text-based learning, which can lead to a failure to adequately cover technology, audio and visual subject matter, and other forms of expression. A too-narrow focus can mislead learners and restrict knowledge acquisition. A broader approach can create unexpected relationships and heighten distinctions between plagiarism, inspiration, fair use, authorship, and inventorship in IP and in relation to rights and responsibilities among students, educators, and participants in collaborations in sciences, engineering, arts, and design.

Suggested Actions: We suggest that those who are developing IP policies in government, private-sector, and university contexts identify and integrate linkages that make it possible for sciences, engineering, arts, and design to be more closely aligned, so as to avoid conflict and exploit opportunities. This would help initiate conversations across disciplines, stimulate a cross-

pollination of ideas, necessarily establish cross-disciplinary relationships, and begin to reveal commonalities and unique expertise while establishing more credibility and respect across disciplines.

We further suggest that local and international governmental copyright and patent agencies more actively coordinate and develop materials on a range of topics and users' needs that overlap with citation conventions, taking into account not only aspects of IP rights and academic honesty, but also proper credits, acknowledgements, and fair use.

5. Obstacle: Different approaches to acknowledging authorship and credit can converge in relation to cross-disciplinary collaborations and cause conflicts in ways that may challenge values and introduce stipulations that potentially limit creativity and experimentation.

Suggested Action: We suggest that scientists, engineers, artists, and designers enter into cross-disciplinary collaborations with an expectation of unique differences, and develop strategies to keep the focus on the collaboration, the project or research itself, and the learning experience. Participants should be sensitive to contexts and existing cultures, with special care when being primarily accommodated in a cross-disciplinary collaboration. Further, participants in cross-disciplinary collaborations of amateur practitioners with professional scientists, engineers, artists, and designers would be wise not only to share their IP experiences and practices, but also to be perceptive about the impact of doing so, in order not to inadvertently impose their conventions without a clear understanding of their influence and impact on their collaborators' culture. From another perspective, in a cross-disciplinary environment that has prescribed IP conventions, artists and scientists should be able to adapt to circumstances, while also being generous in sharing their own experiences. Cross-disciplinary collaboration calls for flexibility, trust, and respect for the wide range of practices used in acknowledging authorship and credit, along with openness and receptivity to the challenges they might pose to an individual's values.

Notes

1. For a list of primary organizers and programs, see artsactive (2012). (Disclosure: co-author Robert Thill is an advisor to artsactive.) For a general overview with a focus on two specific programs, see Kemp (2011). For in-depth analysis of the Arts and Science Research Fellowships Scheme, which was established by the United Kingdom Arts & Humanities Research Board and Arts Council England, in relation to IP, see Leach (2012). For an independent cross-disciplinary collaboration between a technical specialist and n55, an art collective (n55 2012), see Kronick, who articulates a vivid argument for his engineering processes, adding "new meanings" and highlighting his use of open source code as "eschewing copyright norms" and making "a statement against the legal concept of intellectual property" (2010, 7, 10). Kronick's essay is also of interest because it represents the perspective of a collaborator whose role and views are aligned with science and engineering, even though its author was a student of architecture.

2. The recontextualization of theoretical material intended for discipline-specific readership into interdisciplinary contexts can create deceptive relationships, misleading authorship, and confused knowledge (see Beal and Deal 2011).

3. For an examination of collaboration that highlights greater credibility as a motivation in interdisciplinary collaboration, see Maiensche (1993). This text also thoughtfully explores authorship, credit concerns, and layers of contribution in collaborations, and includes examples that involve the sciences and arts.

4. For a useful general glossary of IP-related terms, see Rensselaer Polytechnic Institute (2012); for spirited perspectives on common questions about copyright, especially in an academic context, see Newman (2007).

5. Mitchell, Inouye, and Blumenthal (2003, 101) state that IP agreements were developed for a collaborative work by an artist and a scientist that established co-ownership; however, the authors provide little detail about them.

6. In Crabbe (2004), the functions of IP are discussed in relation to goal-led design research using a case study of an interdisciplinary collaboration between university researchers and a commercial client.

7. This case study is to some extent paraphrased, based on electronic communication with the informant.

8. CEA and the Leti Institute are partners in the Atelier Art Sciences (L'Atelier Arts-Sciences-CEA 2012); this formal undertaking most likely helped create institutional norms that enabled enough openness for the Leti Institute's team to work on art projects, such as Le Moine's, despite his not being involved in their formal program.

9. The project is reproduced at Le Moine (2012), which also includes individual slides of a presentation that documents the project's process (Constancias 2008).

10. For more information on the organization, see C. A. Muller Radio Astronomy Station (2012).

11. For additional material about historic and contemporary uses of moon bounce, including a brief acknowledgement of interest in moon-bouncing images and an observation that artists have generated some of this interest, see Katz and Franco (2011), which also references earlier attempts to moon-bounce images. For those seeking some documentation on the development of this practice, see K2UYH (2013), which also provides insights into amateur radio identity, culture, and crediting norms.

12. The images used by the radio amateur from the U.S. that were not credited were both his own creations that were moon-bounced for him and images created by the collaborators that were moon-bounced and shared with him, including images related to a performance work by De Paulis and CAMRAS (De Paulis, pers. comm.).

13. Van Muijlwijk gives examples of CAMRAS's crediting norms: "Let's say I use certain free software to process radio signals and I get some nice results. When I talk about that I always mention the maker of that software. And if something is written down and published I do the

same. It's more or less second nature. In amateur radio everyone does that" (Van Muijlwijk, pers. comm.).

14. It might be significant to those studying cross-disciplinary collaboration in general to know that the conflict itself and its resolution were reported to have brought the primary collaborators closer together and helped solidify their relationships and create deeper bonds (De Paulis, pers. comm.).

15. Asked about his observations of the response of those in CAMRAS who were strictly amateurs (no professional or science backgrounds), Van Muijlwijk said, "It was not a CAMRAS-wide discussion. Of course some people heard about it and were most of the time rather astonished that we ran into those problems. . . . Most people who heard about it could not understand (like Daniela and me) why [the radio amateur] was not willing to credit Daniela" (pers. comm.). Further exploration of the relationship between a professional artist and radio amateurs raises questions of authority in relation to crediting within cross-disciplinary collaborations and the perception of the designation "professional" and "amateur." Asked about the converging values and acts of the collaboration, the formal credits, and the lack of informal credit by the radio amateur, Van Muijlwijk said it was "difficult" to speculate about it, offering: "We radio amateurs would have noticed [the lack of credits] but maybe a bit later. . . . Daniela, being a professional artist, is more aware of things that can go wrong, so she was the first to notice" (pers. comm.).

16. In considering these aspects of their crediting requirement, it bears repeating that their original research was appropriated.

17. In the context of a discussion of formalized IP policies, Van Muijlwijk communicated the following in relation to moon-bouncing: "Now that the dish is nearly fully restored we (CAMRAS) will have to do the maintenance in future. That will cost money, of course. So we are looking for ways to make some money. There are all kinds of ideas, but one of the ideas is asking for some money from artists and astronomers who want to use the dish. CAMRAS volunteers can use the dish for free, so if Daniela is one of CAMRAS, she won't have to pay for dish-time in future" (pers. comm.).

18. Noting the effect of the decision, Van Muijlwijk stated, "I had that sense of getting less free by enforcing the crediting. That was not a nice feeling. Very opposite to what amateur radio feels like" (pers. comm.).

19. De Paulis describes CAMRAS and her public activities in relation to part of her artistic goals as follows: "CAMRAS and I have been very active in making public the technological insights of what we do, both through public presentations and published papers. Jan [Van Muijlwijk] especially has been helping lots of radio amateurs across the world getting their gear set for moon-bouncing images. We hope that more and more radio amateurs will catch up, to the point where moon-bouncing images will become a more popular way of communicating. This is very much part of my artistic aims too" (De Paulis, pers. comm.). Here, one can see how the practical need to protect cross-disciplinary collaborative works

and the desire to promote them converge, and the quandary this convergence can pose for creative intentions.

20. Van Muijlwijk has made a representative statement about the innovation and the credit issue: "Your image was altered by 'our' process, so when publishing the end product it would be polite to mention how the alteration came about" (pers. comm.). Here, he more emphatically underscores the innovation as collaborative, appears unambiguous about publishing, and highlights the process that would only come about through cross-disciplinary collaboration, potentially giving the technological process a bit more weight than he does in other statements in which the artist's idea seems primary. This seems consistent with a trace of modesty and a hint of wonderment in relation to collaborating with an artist. Viewing the situation through the prism of politeness rather than in the legal and academic language of IP rights and authorship seems to emphasize the desired social dynamics and values among the radio amateurs.

21. When asked if there is discussion about the contrast between the free culture of amateur radio and the monopolistic influence that ASTRON, CAMRAS, and De Paulis have on the Dwingeloo dish to moon-bounce or not to moon-bounce images, Van Muijlwijk said, "No, not much discussion about that, that I am aware of. But we must realize we are just at the beginning of this. The first ever try to moonbounce pictures in Dwingeloo was in 2009" (pers. comm.).

References

artsactive. 2012. "Network." Accessed September 15. http://www.artsactive.net/en/network/.

L'Atelier Arts-Sciences-CEA. 2012. Accessed December 9. http://www.atelier-arts-sciences.eu/.

Beal, Timothy, and William E. Deal. 2011. "Theory, Disciplinarity, and the Study of Religion: Lessons from Publishing Nightmare." Journal of the American Academy of Religion. 79 (4) 1050–1064. doi:10.1093/jaarel/lfr037.

Blackwell, Tim, and Janis Jefferies. 2006. "Collaboration: A Personal Report." CoDesign 2 (4): 259--263. doi:10.1080/15710880601008075.

C. A. Muller Radio Astronomy Station (CAMRAS). 2012. CAMRAS. Accessed September 18. http://camras.nl/.

Constancias, Christophe. 2008. Projet artistique calligraphie: 'Un autre monde . . .' nano. PowerPoint file. Grenoble, France: CEA.

Crabbe, Anthony. 2004. "Contract Research in Design." Design Issues: 20 (4): 57--67. http://www.jstor.org/stable/1512002.

De Paulis, Daniela. 2012. Opticks (blog), in collaboration with Jan van Muijlwijk and CAMRAS. Accessed September 18. http://www.opticks.info.

Jackson, Myles W. 2003. "Can Artisans Be Scientific Authors?: The Unique Case of Fraunhofer's Artisanal Optics and the German Republic of Letters." In Scientific Authorship: Credit and Intellectual Property in Science, edited by Mario Biagioli and Peter Galison, 113--131. New York and London: Routledge.

Japan Patent Office, Asia-Pacific Industrial Property Center, and Japan Institute of Invention and Innovation. 2008. Intellectual Property Education as a Means to Nurturing Creativity. In collaboration with Haruhisa Uchida. Japan Patent Office. Accessed September 9, 2012. http://www.training-jpo.go.jp/en/uploads/text_vtr/pdf/Education.pdf.

K2UYH. 2013. "432 and Above." EME Newsletter Archives. Accessed April 30. http://www.k2uyh.com/news.htm.

Katz, Allen, and Marc Franco. 2011. "Targeting the Moon." IEEE Microwave Magazine. 12 (4): 62--73. doi:10.1109/MMM.2011.940592.

Kemp, Martin. 2011. "Culture: Artists in the Lab." Nature 477: 278--79. doi: 10.1038/477278a.

Kronick, Samuel. 2010. On the Aesthetics of Technology and Engineering in Collaborative Conceptual Practice. Program in Writing and Humanistic Studies. Massachusetts Institute of Technology. Accessed November 9, 2012. http://writing.mit.edu/sites/writing.mit.edu/files/Aesthetics%20of%20Technological%20 Conceptual%20Collaboration%203.pdf.

Le Moine, Guillaume. 2012. Un autre monde, 2008. "Works." Guillaume le Moine. Accessed November 22. http://guillaumelemoine.org/albumphoto5/index.html.

Leach, James. 2012. "Constituting Aesthetics and Utility: Copyright, Patent and the Purification of Knowledge Objects in an Art and Science Collaboration." HAU: Journal of Ethnographic Theory 2 (1): 247--68. Accessed October 10, 2012. http://www.haujournal.org/index.php/hau/article/view/23/140.

Maiensche, Jane. 1993."Why Collaborate?"Journal of the History of Biology 26 (2): 167--183. http://www.jstor.org/stable/4331258.

Mandel, Gregory N. 2010. "Left-Brain versus Right-Brain: Competing Conceptions of Creativity in Intellectual Property Law." U.C. Davis Law Review 44: 283. 2010. Temple University Legal Studies Research Paper 2010-8. Social Science Research Network. Last modified November 24, 2010. Accessed September 14, 2012. http://ssrn.com/abstract=1588214.

Marušić, Ana, Lana Bošnjak, and Ana Jerončić. 2011. "A Systematic Review of Research on the Meaning, Ethics and Practices of Authorship Across Scholarly Disciplines." PLoS ONE 6 (9): e23477. Accessed November 25, 2012. doi:10.1371/journal.pone.0023477.

Merges, Robert P. 2011. Justifying Intellectual Property. Cambridge, MA: Harvard University Press.

Mitchell, William J., Alan S. Inouye, and Marjory S. Blumenthal, eds. 2003. Beyond Productivity: Information, Technology, Innovation, and Creativity. Washington, D.C.: The National Academies Press. n55. 2012. "n55 Manuals." "Manual for WALKING HOUSE." Accessed November 9. http://www.n55.dk/MANUALS/WALKINGHOUSE/walkinghouse.html.

Newman, Paul. 2007. "Copyright Essentials for Linguists." Language Documentation and Communication 1 (1): 28--43. Accessed December 16, 2012. http://scholarspace.manoa.hawaii.edu/bitstream/handle/10125/1724/newman.pdf.

Oliar, Dotan, and Christopher Sprigman. 2011. "Intellectual Property Norms in Stand-Up Comedy." In Making and Unmaking Intellectual Property: Creative Production in Legal and Cultural Perspective, edited by Mario Biagioli, Peter Jaszi, and Martha Woodmansee, 385--98. Chicago: The University of Chicago Press.

Online Ethics Center for Engineering. 2006. Teaching the Individual Engineer About Fair Credit and Intellectual Property. National Academy of Engineering. Accessed November 9, 2012. http://www.onlineethics.org/Education/instructguides/18934/credit.aspx.

Rensselaer Polytechnic Institute. 2012. "Division of Finance," "Research," "Intellectual Property Resources." Glossary of Intellectual Property Related Terminology. Accessed December 11. http://www.rpi.edu/dept/finance/docs/research/GlossaryIntellectualProperty.pdf.

Smithsonian Institute, Office of Policy and Analysis. 2010. Interplay of Perspectives: History, Art & Culture + Science: Interdisciplinary Crossover and Collaboration. Smithsonian Institute. Accessed September 22, 2012. http://www.si.edu/content/opanda/docs/Rpts2010/10.09.HACSci.Final.pdf.

Velonaki, Mari, David Rye, Steve Scheding, and Stefan Williams. 2008. "Fish-Bird: Cross-Disciplinary Collaboration." IEEE MultiMedia 15 (1): 10--12. doi:10.1109/mmul.2008.7.

Weinberg, David H. 2011. "From the Big Bang to Island Universe: Anatomy of a Collaboration." Narrative 19 (2): 258--72. doi:10.1353/nar.2011.0008.

Sauti Ya Wakulima: Using Mobile Phones to Make the Voices of Rural Farmers in Tanzania Heard

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Context

E-agriculture defines an emerging field in which information and communication technologies (ICT) are applied to the improvement of agriculture and rural livelihoods. The term was introduced as one of the key areas of application of ICTs in the Plan of Action of the World Summit on the Information Society (WSIS), celebrated in Geneva 2003. In that document, the aims of e-agriculture were to apply ICTs to the dynamic dissemination of accessible, up-to-date information on agriculture, particularly in rural areas, and to use these technologies as instruments to increase food production, both in quantity and quality (WSIS, 2003).

Mobile communication technologies are presently the main focus of e-agriculture. In Africa, where most of the development projects for agriculture are concentrated, internet usage is still low, reaching about 13,5% of the population; yet it has grown 2'357% over the last ten years, almost five times more than the rest of the world (Internet World Stats, 2011). However, more than a third part of the population in Africa are mobile phone owners, and this rate is growing fast (International Telecommunications Union, 2010). According to their farmer-centered research, Furuholt and Matotay (Furuholt, Matotay, 2011) identify five key areas in which mobile technologies become useful: 1. Accessing timely information, 2. Making markets more efficient and transparent, 3. Providing advance warning of weather and other risks, 4. Accessing complementary services, such as mobile banking, and 5. Aiding in general communication and coordination.

In our research, we aim to reveal and provide an alternative to the underlying values of most e-agriculture projects in Africa, which tend to regard farmers as mere clients of expert-generated information. We have argued that the unidirectional communication designed into these projects may effectively devalue the traditional knowledge held by farmers, in favor of purely techno-scientific solutions1. Moreover, our research recognizes the calls made by a number of scientists, who have recognized the necessity of integrating traditional knowledge into the design of local strategies for development and adaptation to complex challenges such as climate change (Jones et al., 2005).

Description of the project.

Sauti ya wakulima2, "The voice of the farmers" in Swahili, is an e-agriculture project which directly addresses the socio-agricultural context of rural communities in Tanzania. The project was started in January 2011, when we traveled to Tanzania to conduct a series of interviews with farmers living near the town of Bagamoyo, with the purpose of engaging them in the creation of

an online, collaborative knowledge base about the effects of climate change, using smartphones as tools for observation and a web page to gather the recorded images and sounds. Accompanied by Dr. Flora Ismail from the Botany department of the University of Dar es Salaam, and Mr. Hamza S. Suleyman, the local extension officer, we held a meeting with a group of farmers that regularly gather at the Chambezi agricultural field station in the Bagamoyo District. At this meeting, the project and its goals were explained to the farmers. Despite the fact that none of them had accessed the internet before, they had all heard of it largely through the younger members of their communities. They quickly understood that the images and sounds uploaded from the smartphones would not only be visible to them, but to anyone who visited the project's web page. After deliberating, the farmers voted unanimously in favor of taking part.

We established the project's dynamics together with the farmers, and carried out the first training session on how to use the smartphone and the project's web page. A group of five men and five women chosen by the community would take turns to share the two available smartphones, by exchanging them on a weekly basis. Whenever a farmer's turn to use the phone arrived, he or she would have the task of using it to contribute content to the knowledge base. These contents consist of units, which we call messages, comprised of a picture, a voice recording and an optional keyword. A special application running on the smartphones makes it easy to capture the multimedia elements. It also integrates geographical information into the message (if available), allows the addition of one or more keywords and sends all the elements to a web server, bundled together as an email message. By using pictures and voice recordings, farmers can portray a wide variety of objects, situations and persons, and complement visual evidence with their own spoken narrations.

Farmers not only got together to exchange the phones but also to see and discuss the pictures and voice recordings that the group had uploaded during the week. There, they accessed the project's web page using a laptop computer with a mobile broadband connection. As of this writing, the farmers in Chambezi were continuing to use the smartphones to publish content. After 21 months, Sauti ya wakulima now runs in a semi-autonomous fashion, and is partially supported by the local government in Bagamoyo.

Outcomes

In our analysis of the contents published by the farmers, we confirmed that the farmers used the smartphones mostly to interview other people. In these interviews, fragments of knowledge and even manifestations of creativity (such as the invention of a shelling machine or experimentation with intercropping) were revealed. The phones were also used to provide visual evidence of problems such as pests, plant diseases or the scarcity of water, and to advertise products or services. The diversity of topics addressed by the farmers reveals the extent to which the farmers appropriated both the communications tools and the originally proposed goals of the research. Appropriation can be considered as indicator for usefulness and meeting the needs of the targeted community as it can deeply affect the politics of their daily lives. In a context where communication technologies play an active role in development, it can be seen as a starting point for community empowerment (Bar, Pisani and Weber, 2007).

The farmers found that documenting their practices and problems through interviews could lead to the creation of a shared, audiovisual knowledge base, which they could use for various purposes including learning, consulting of farming practices, promotion of farming inputs and even extending their social networks. Farmers also saw the project's potential for reporting problems, such as pests or construction of wells, to the extension officers and/or government officials in order to get timely assistance. The Agricultural Office in Bagamoyo found this application to be particularly relevant. According to an official report, one of the greatest weaknesses in the local agricultural infrastructure is the lack of sufficient extension officers. Currently, there is a ratio of 1 extension officer per 1,145 farmers, almost half of the ideal ratio, established by the office at 1:600 (Bagamoyo District Council, 2011). In response to this expressed interest, the local government in Bagamoyo has agreed to financially support the project, by providing funds to cover the expenses generated by the usage of smartphones. Additionally, the local government has provided a number of grants to the farmers who participate in Sauti ya wakulima, encouraging them to document farmers' shows and agricultural fairs in Bagamoyo and other villages.

Suggested actions and lessons learned

These actions are aimed at planners, designers, researchers and on-the-ground personnel involved in the development of e-agriculture projects.

1. Consider farmers as generators of knowledge. The design of most e-agriculture projects currently being developed does not encourage the integration of local farmer-held knowledge into a larger body of agricultural knowledge. This may affect farmers in a negative way by eroding their own systems of knowledge and traditional social structures. Agriculture is a complex field that requires much more than technical expertise. Thus, e-agriculture initiatives can be made more effective by embracing holistic values that also include social elements and traditional knowledge.

2. Fully exploit the interactive capacity of mobile media. Most e-agriculture initiatives do not contemplate a multi-directional model of communication, in which every node of the network can be both a consumer and producer of information. Generally, expert information is made accessible to farmers who, only in some cases, are allowed to get replies for specific questions. However, mobile networked communications media have the potential to break this hierarchical mode of transmission, and engage all involved parties in more equal terms.

3. Deploy highly experimental and innovative e-agriculture projects as small-scale initiatives. One of the key concerns in e-agriculture is the usage of so-called "realistic" technologies, meaning that high-end platforms such as smartphones or data networks should be avoided, because they are not available to the majority of farmers. Despite the fact that robust and reliable digital networks are still largely missing in Tanzania and other countries, and that the cost of devices and data connections can be prohibitive for most farmers, projects such as Sauti ya wakulima aim to explore new possibilities through the innovative and experimental usage of these relatively sophisticated tools. In contrast with other e-agriculture projects, which seek to impact large numbers of people, Sauti ya wakulima has engaged a small group of very focused farmers willing to test new communications technologies.

4. Encourage the appropriation of media tools and scientific research goals. As we have argued, the appropriation of communications media by a community can lead to its empowerment. Therefore, farmers should be encouraged to not only become users of mobile networks, but also to reshape their usage to best suit their needs. This effort requires adequate training and the design of platforms which embrace open-source values. As a parallel action, we suggest that research projects be designed in ways which allow farmers to lead their goals and share their outcomes together with scientists.

5. *Technical difficulties*
   We encountered a number of technical problems. On two different occasions, we had to replace a phone which had stopped working because of extreme weather and environmental conditions. The phone cameras do not focus on macro level and so details of insects and fungus were lost. However, the most important limitations of Sauti ya wakulima are achieving a stable financial sustainability and devising a scheme to scale up the project in order to involve other groups of farmers.

References

Bagamoyo District Council, 2011. Agricultural Sector Development Programme and District Agricultural Development Plans for 2011/2012, Bagamoyo District Council, Bagamoyo.

Bar, F., Pisani, F., Weber, M., 2007. Mobile technology appropriation in a distant mirror: baroque infiltration, creolization and cannibalism. http://arnic.info/Papers/Bar_Pisani_Weber_appropriation-April07.pdf (accessed 07.11.2012)

Furuholt, B., Matotay, E., The developmental contribution from mobile phones across the agricultural value chain in rural Africa. The Electronic Journal of Information Systems in Developing Countries, vol. 48, issue 7, pp. 1-16.

International Telecommunications Union, 2010. The World in 2010: ICT Facts and Figures. http://www.itu.int/ITU-D/ict/material/FactsFigures2010.pdf (accessed 07.11.2012)

Internet World Stats, 2011. Internet Usage Statistics for Africa. http://www.internetworldstats.com/stats1.htm (accessed 07.11.2012)

Jones, P., Amador, J., Campos, M., Hayhoe, K., Marín, M., Romero, J. & Fischlin, A., 2005. Generating climate change scenarios at high resolution for impact studies and adaptation: Focus on developing countries. In: Saloh,Y., Robledo, C. & Markku, K. (eds.), Tropical forests and adaptation to climate change: in search of synergies. Island Press, Washington.

World Summit on the Information Society (WSIS), 2003. Plan of Action. http://www.itu.int/wsis/docs/geneva/official/poa.html (accessed 07.11.2012)

Vitamin A: A Modest Proposal to Introduce Trace Amounts of Contemporary Art into Research by Preparing Students in Art, Design, Engineering, and Science for Collaborative Creative Work, With the Intention of Saving Earth

http://wp.me/P2oVig-oB

Coordinator: Meredith Tromble

Abstract

Meeting global challenges such as climate change requires cultural, "human-factor" innovation as well as technological invention [1]. Integrating our knowledge resources in order to respond to the full scope of the challenges may increase the lifespan of our culture and the tenure of life on Earth. Rather than advocating for a defined form of knowledge integration, this paper proposes extending the basic toolkit of creative practitioners so that they can select and adapt the forms of knowledge integration to suit their problems. The intent is to reduce the conceptual barriers between domains. In particular, contemporary art's emphasis on critique, paradox, and poetic thinking has made it an uneasy fit for educational systems rooted in a rational, modernist world view [2]. These qualities, however, may facilitate the paradigm-shifting imaginative leaps required by our most difficult problems. We propose mapping the field of collaborative research and introducing students to a schema that interrelates their creative areas and introductory experience with cross-disciplinary collaboration. A flexible coursework structure, designed to partially fill a "hole" in our educational system, is suggested, as research shows that currently most collaborations arise through chance and personal relationships [3]. While these factors will continue to be important in forming collaborations, we recall Louis Pasteur's famous saying that "chance favors the prepared mind." Furthermore, as standard organizational forms, such as school departments, academic conferences, and even white papers, exert subtle influences channeling thought along familiar paths, to develop and disseminate the map and coursework guidelines we suggest conceiving as an art event a cross-disciplinary symposium [4]. In this spirit of formal innovation, we stretch slightly an accepted form of knowledge transmission—the white paper—augmenting the straightforward narrative with a chorus of quotes embodying voices from different domains of knowledge (and a bit of humor in our title).

Introduction

"...knowledge has to be organized so that it can be taught, and it has to be reduced to information so it can beorganized...this leads you to assume that organization is an inherent property of the knowledge itself, and that disorder and chaos are simply irrelevant forces that threaten it from the outside. In fact it's exactly the opposite. Order is simply a thin, perilous condition we try to impose on the basic reality of chaos..."

— writer William Gaddis , from the introduction to   his novel *J.R.*, Dalkey Archive Press Edition, Champaign, 1971/2012, p. 20

What does Gaddis mean by the "thin, perilous condition" of the order we impose on knowledge, and what does this have to do with training for collaborative research? The sense of his statement may be illuminated by reflecting on this list of 12th century liberal arts: "grammar, rhetoric, dialectic, arithmetic, astronomy, music, and geometry;" [5] it outlines a different knowledge universe than the one with which we are familiar. It seems certain that scholars in 3012 will find our disciplines, our recipe for ordering knowledge, as redolent of our century as the list is of the 12th.

As we propose core course elements for preparing artists, designers, engineers, and scientists for collaborative research, the first point is to ***emphasize that categories of knowledge such as "fine art", "graphic design," "astrophysics", or "mechanical engineering" are themselves the collaborative creative productions of our society.*** And as human creations, they are not immutable but are, excitingly, subject to change and development. In our historical moment, digital tools are enabling and driving new forms of research. The students who respond to the opportunity to think beyond the research traditions of their discipline—and we intend this work for advanced students, who, being grounded in the methods of their field, can share them with others—have the opportunity to contribute to this restructuring of knowledge.

The collaborative turn

"Researchers, like most ordinary people, tend to identify with their ingroup and ignore or even look down onneighboring disciplines. Yet most relevant topics we study today do not respect the historically grown disciplinary borders, and to make progress one must look beyond one's own narrow point of view."
— psychologist Gerd Gigerenzer, Director at the Max Planck Institute for Human Development from *Gut Feelings: The Intelligence of the Unconscious*, Viking, New York, 2007, p. 77

What we refer to as the "collaborative turn" can be tracked through developments in the English language. According to the 2011 Random House Dictionary, the word "interdisciplinary" first came into use during World War II, between 1935 and 1940, as a way to identify the mixing of knowledge disciplines and professions. Inter- has been joined by trans- and cross- disciplinary subjects and together they have spawned a welter of pursuits that didn't exist in 1940: anthrozoology, astrobiology, bioinformatics, cognitive linguistics, computational chemistry, evolutionary literary theory, medical cybernetics, neuroaesthetics... in the sciences, the list of recombinant disciplines continues to grow.

Within fine art, hybrid media are now the norm. Considering that nearly three-quarters of the artists in one of the world's major international art exhibitions, the Venice Biennale, draw on multiple disciplines including performance, film, and writing, "pure" painting and sculpture could be considered minority disciplines [6]. And within art scholarship, "world art studies," a global and multidisciplinary approach to visual art that draws upon anthropology, archaeology, evolutionary biology, psychology, and other fields in addition to art history, is emerging. [7]

The first rumblings of these changes roughly coincide with the development of cybernetics, information theory, and other sources of today's digital technologies in the decade following World War II. The onslaught of "big data" that has ensued has increased the need for

sophisticated visualization in science, raised new philosophical issues for society and therefore for artists, and given creative people in all fields powerful new tools. In this atmosphere of intellectual and societal change, it is not surprising that questions — research agendas, artistic inquiries, engineering problems, or design programs — that require information and methods from more than one arena are both more frequent and more important.

Some research suggests that while interdisciplinary collaboration is more challenging than working in homogeneous groups, when interdisciplinary groups are successful they produce greater innovation. The general knowledge and skills necessary for successful cross-disciplinary collaboration are therefore of increasing importance in all creative fields. *The second foundational element is to* **present a cultural overview relating the study of collaboration to contemporary conditions and the currents of change in all knowledge fields.**

Creativity and the relationship between domains

"Boundaries are the locus of the production of new knowledge. They are where the unexpected can be expected, where innovative and unorthodox solutions are found, where serendipity is likely, and where old ideas find new life."
— computer scientist Gerhard Fischer,
from "Social Creativity: Turning Barriers into Opportunities for Collaborative Design,"
http://l3d.cs.colorado.edu/~gerhard/papers/pd04-final-submit.pdf [Accessed 10.25.12]

*"Our job is to create language to speak to each other with respect."*
— innovator Rich Gold, quoted in "Truth, Beauty, Freedom, and Money," a report by Michael Naimark for Leonardo Journal, p. 8

Some time in the 1990s, Rich Gold, who was a primary researcher on ubiquitous computing at Xerox PARC and the manager of the PARC artist-in-residence program (PAIR), created this diagram comparing the creative fields of art, design, engineering, and science, as they are practiced in Western culture.
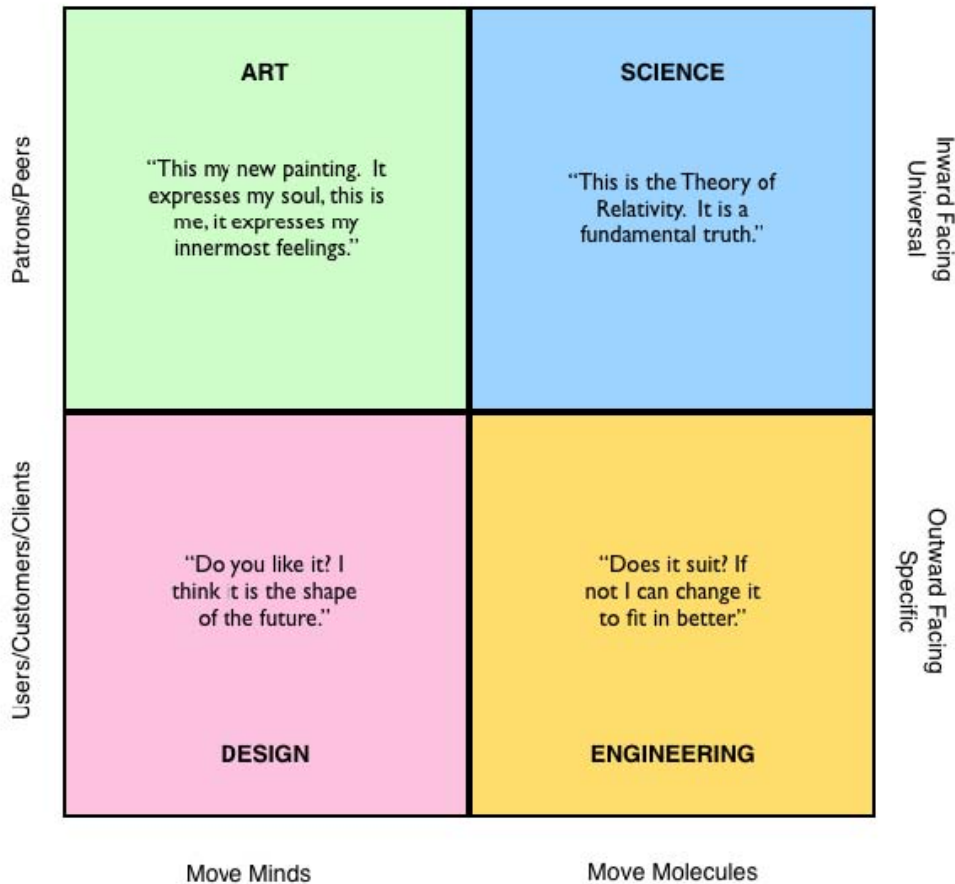
Rich Gold's original matrix relating creative domains

Gold's ideas were informed by his leadership experience in one of the most famously innovative interdisciplinary research centers of the twentieth century; thus they are a good starting point for considering education for collaborative creativity. But as discussed in the introduction, the organization of our cultural knowledge into categories is not fixed. When Gold formulated his matrix, he stereotyped the key ideas in the interests of clarity.* Decades later, each of the four sectors has been influenced by the "postmodern" or "post-colonial" ideas that developed in tandem with digital culture. Gold's pithy summaries now allude to the past rather than the future. Thus we offer an updated version of his matrix.
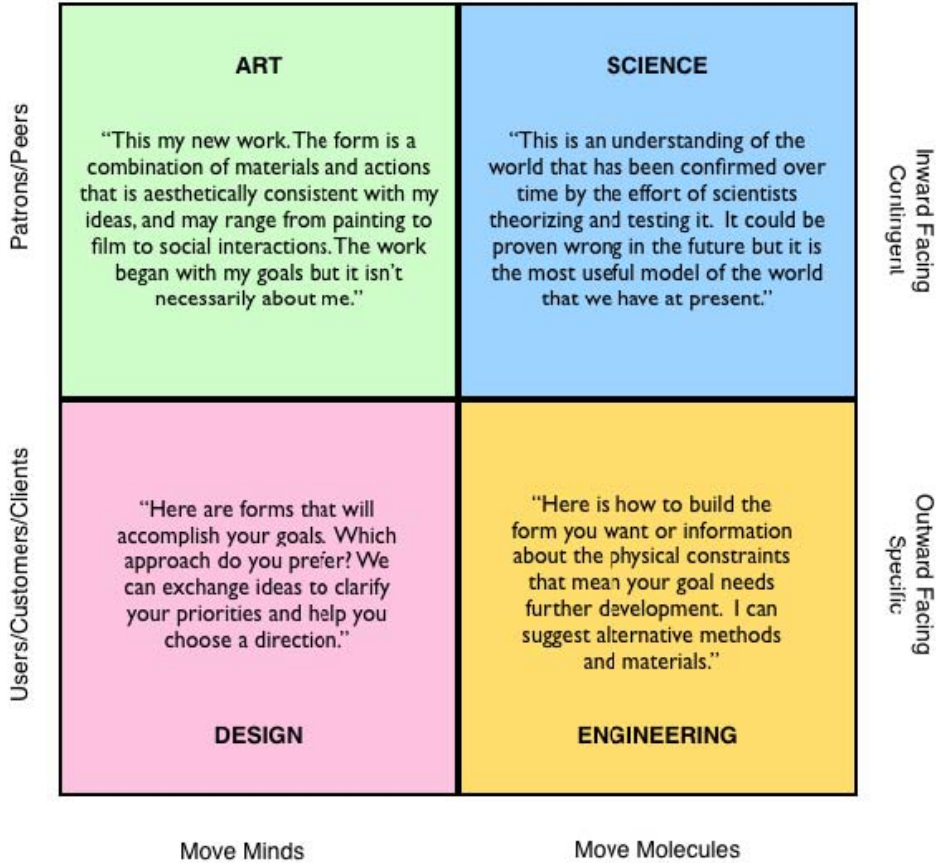
Updated version of Gold's Matrix

Gold identified "self-expression" as the core of "Art"; contemporary artists may or may not incorporate "self-expression" in their practice. They operate within a greatly expanded field of material production which incorporates actions, digital games, lens-based media, and installation in addition to painting, printmaking, and sculpture. Conceptually, following the practice of artists such as Marcel Duchamp, artists aim to produce experiences and objects that stimulate emotion and thought, what evolutionary biologist Ellen Dissayanake would call "making special" [8].

In "Science," Gold gave the key idea as "universal truth." While the search for verifiable, repeatable results that hold true for our known world is still the heart of science, there is also a greater awareness of the limits of empiricism. The minds reasoning from data are human and the history of science offers many cautionary tales of scientific investigations distorted by cultural blind spots [10]. Therefore, we have used language that emphasizes exploration, rather than authority, for the matrix.

If one keeps in mind that the boundaries between "Art" and "Design" have blurred considerably since the time of Gold's matrix [9], his formulations for "Design" and "Engineering" are still close to the mark. But we have more articulated theories describing our use of the information

embedded in our environment through design. (Here, we are thinking of the work of cognitive scientist Edwin Hutchins [10] and anthropologist Lucy Suchman [12], among others.) And the domain of engineering has been enlivened by "hacking," the "reverse engineering" or unraveling and reworking of commercialized technologies in order to use them for other purposes than those for which they were originally intended. "Hacking" thereby questions values and social structures that are generally taken for granted, bringing a philosophical edge to engineering [13]. So Gold's "Design" and "Engineering" tags have been reworded to convey a greater sense of agency, with more emphasis on the creative contributions of designers and engineers.

In addition to changes within creative domains, the understanding of what it takes to be "creative" in *any* domain has shifted. The modernist model of creative "genius" in which innovation is attributed to the creative insight of one individual has yielded to a model of exceptional accomplishment in which individual ability is a necessary but insufficient condition of achievement, always modified by social and historical conditions [14].

Indeed, the importance of historical conditions has been suggested by the difficulty of recreating successful collaborations such as Xerox Parc, the organization of which Gold was a part. One such effort, Interval Research, was generously funded by entrepreneur Paul Allen in hope of mimicking Xerox Parc's success in generating the "technology that will be important in the future." The desired innovations failed to materialize, despite the number of brilliant individuals and the collaborative opportunities involved, and after seven years the pure research program was discontinued. [15]

While all four of our creative sectors value invention, it is rare for their educational tracks to include a study of creativity per se. Thus the third point in our guidelines is to ***offer participants an understanding of creative practice that relates their domains, acknowledging key points of similarity and difference, and considering the multi-dimensional factors involved in creative success.***

The Gold Matrix demonstrates the potential of visual diagrams to quickly communicate such interrelationships. Since Gold's time, the science of science has yielded detailed visualizations of interconnected themes and thinkers within science, such as those described in Katy Börner's *Atlas of Science: Visualizing What We Know* (MIT Press, 2010). Our scientific authors wondered how collaborating with an artist might contribute to research, although they could easily see the value of an artist/designer in disseminating scientific work to the public. A map of cross-disciplinary, collaborative research would be a powerful tool to quickly demonstrate the potential of such investigations.

Unlearning and flexible role-playing

"...you are always going to be accused of being superficial, of reinventing the wheel, of never knowing enough about any one discipline...that would be true if you had to know everything about a discipline to understand how it worked-- and I don't think that is."

— Anonymous research collaborator and research subject, quoted in Lisa R. Lattuca, *Creating Interdisciplinarity: Interdisciplinary Research and Teaching among College and University Faculty,* Vanderbilt University Press, Nashville, 2001, p. 124

"Unlearning" may be as valuable to a creative group as learning. Given that general cultural knowledge will necessarily lag behind the most advanced research and creative production, and that to some degree artists, designers, engineers, and scientists are a "general public" to each other's fields, students may hold ideas regarding each others' domains that are not completely current. (For example, a scientist might think of art in terms of traditional media.) Students may also have ideas about their own discipline or decision-making based in past practices ("engineering is not a creative activity"), ("an artist should not be influenced by others"). "Unlearning" ideas that limit creative exchange is a continuing process, but the fourth guideline is intended to set that process in motion: ***Stimulate awareness of the models of "good science", "good art," "good design" and "good engineering" participants have in play through discussion of their aspirations (their values) and exemplars (best practices).***

Even when collaborators have congruent interests and abilities, as might be the case for a new media artist and a computer scientist, in respect to the total knowledge of the group (even a "group" of two), each collaborator will be expert in some areas and amateur in others. These "knowledge gaps" create opportunities for fresh questions and insights but also require negotiation of leadership. In what we will call "instrumental" collaborations, where one type of knowledge is programmatically at the service of another (an artist illustrating a scientific finding, a scientist programming for an artist's project, a designer making slides for an engineer's presentation, an engineer creating material specifications for a designer's product), creative leadership is effectively determined by the end goal.

Difficult problems that require an innovative approach, however, benefit from an improvisatory decision-making structure in which leadership roles shift according to the evolving needs of the research.

[16] A fluid exchange of collaborators between leading and supporting roles may be necessary to make the most effective use of the group's skills. Thus the fifth guideline: ***Build students' repertoire of decision-making models by presenting varied historical examples of cross-disciplinary collaboration.***

The discussion of models might range from the structured, large-scale professional collaboratories of a space mission as described by Benjamin Shaw [17] or the equally large-scale participatory and improvisatory performances organized by the art and programming group Blast Theory [18]**,** to a small-scale partnership such as that between physicist James Crutchfield and sound artist David Dunn, which has produced both scientific papers [19] and performances**.** It might include long-lived collaborations such as Ant Farm [20], or project-based collaborations such as engaged in by the Raqs Media Collective, a group of three filmmakers who collaborate regularly with people from other professions [21]**.** It might include partnerships that are both professional and personal, such as that of physicist James Gimzewski and artist Victoria Vesna [22] and agonist** relationships such as emerged in a group of rocketry pioneers, between Frank Malina and Jack Parsons. (The tenor of their work together was described by M.G. Lord: "The

converse styes of Malina and Parsons were as essential to their motor as fuel and oxidizer. Yet they often led to conflict.") [23] Collaborators might work together in person or through commercial communication tools such as Skype or with specialized tools such as the software developed by Julien Phalip, Ernest A. Edmonds, and David Jean to support remote collaboration in film scoring. [24]

We go into some detail with the examples above to demonstrate that there is no one recipe for structuring "hot groups," as organizational psychologist Harold Leavitt termed particularly energized and inventive collaborations [25]. While business and management literature (Leavitt was professor in the business school at Stanford University and a pioneer in the study of organizational behavior) includes many valuable studies of collaborative practice, popularizations of that literature often tender formulaic interpretations that may be part of the material students need to question or "unlearn."*** "Brainstorming," for example, is a group process that has entered into popular awareness as a route to creative ideas, despite research showing that generating ideas individually, before working on them with a[group, is more productive [26].

From theory to practice

The difference between theory and practice is greater in practice than in theory.
— Anonymous, quoted by artist Simon Pennyhttp://simonpenny.net/wisdom/index.html

As the guidelines turn from theory to practice, the hubris of the attempt to compress such a complex study into seven points looms. Framing guidelines so fundamental that they can be applied across different time scales, and so potent that they might assist deep innovation, is the work of dreamers. Yet dreaming is consistent with our call to consider aspects of human experience that resist logic and measurement in tandem with the aspects that are amenable to reason. Acknowledging that the experience of collaboration that is possible in a workshop setting will be brief compared to the experience of a semester-long course, which is a small slice of the time that may be required to incubate a fruitful idea in the "real" world of research, we forge ahead to our sixth guideline: ***Define project groups and give participants an active experience of working together, at whatever scale circumstances allow.***

Defining research questions and goals

"The formulation of a problem is often more essential than its solution... To raise new questions, new possibilities, to regard old questions from a new angle, requires creative imagination and marks real advance in science."
— Albert Einstein & Leopold Infeld, from *The Evolution of Physics*, 1938, p. 92

"Gaps in our understanding (shared or individual), are continually revealed to us through the process of collective sustained enquiry. Once those gaps are identified, the creativity comes in trying to provide artefacts we can find; relationships, metaphors, processes, functions, images and so on, in an attempt to fill them. This is done together, and often for each other."
— Jane Prophet and Mark d'Inverno, from "Creative conflict in interdisciplinary collaboration: interpretation, scale and emergence," http://www.academia.edu/193448/e[Accessed 10.26.12]

At the point of defining research questions, the most extreme differences between domains emerge. Artists typically address questions that have multiple and unstable "answers;" scientists typically define questions so that a stable answer is possible. Designers and engineers are often asked to begin work on a question that has already been defined. As articulated by artist Jane Prophet and computer scientist Mark d'Inverno in the quote above, from a paper on the work of their interdisciplinary stem cell research group, the discussion required to frame a problem together is a key part of the research process.

For our guidelines we assume that the degree of freedom project groups have in identifying problems is subject to instructors' judgment of the participants' skills and the particular educational situation; in a course for undergraduates beginning with suggested questions might be most effective while a workshop for postgraduates might at this point concentrate on developing questions together. We emphasize that while time may limit the experience to framing research questions or allow pursuing a research plan, the key educational component here is the experience of approaching a problem together. In situations that allow extended investigation, the variety of goals to which one group might aspire is shown by this list of outcomes from Prophet and d'Inverno's group: *1) sole and co-authored papers in peer-reviewed medical journals, mathematical modelling journals, simulation journals, art journals and interdisciplinary journal 2) a mathematical model of the new paradigm 3) a dynamical simulation of the mathematical model 4) art installations exploring the nature of scientific representation 5) innovative interactive devices and systems: namely 3D illustrations of cells and their behaviour generated using Alife techniques 6) detailed documentation of all the processes involved in this project* [27]

Assessment and the role of failure in success

"*...we are introducing engineers to some unfamiliar behaviors: creative problem-solving using intuition, guesswork and a cheerful tolerance of failure.*"
— S. Shankar Sastry, Dean of the College of Engineering, University of California, Berkeley "Innovation by Design," *BerkeleyENGINEER*, University of California, Fall 2012 Vol. 2, p. 1

It will come as no surprise that the seventh and final guideline calls for reflecting and crystallising the experiences of the group in a form that participants may usefully recall as they go on about their careers. However, the form that we suggest is particular to the goal of building group creative process: ***Ask participants to articulate in verbal or visual form the failures and successes of their work together*** by the standards of other group members*, as they understand them, and exchange with the group regarding their conclusions.* Given the cultural tendency to emphasize experiences defined as
"success" over experiences defined as "failure," leaders may need to model giving respectful attention to "failure" and "gaps in understanding," which as Prophet and d'Inverno so beautifully express in the passage quoted above, hold the potential to inform better questions.

Suggested actions

The paper began with a proposal for flexible coursework guidelines, intended to seed knowledge of methods and models of cross-disciplinary collaboration in the creative communities of art, design, engineering, and science. In preparing the guidelines, the authors identified the additional need for a "map" that could be used to efficiently alert researchers to the potentials of cross-disciplinary collaboration, organizing the history of such knowledge co-production. The guidelines and map are intended as tools to enhance communication and stimulate vision, making it easier for researchers to jump over the obstacle of disciplinary "silos."

1. We suggest that a consortium of universities and art schools sponsor a year-long collaborative research project joining researchers knowledgeable in the "science of science" with scholars of art, science, and technology, and information designers, to undertake the scholarly and visual mapping of the themes and paradigms of collaborative art, science, and technology work over the past twenty years. (cf the "Map of Scientific Paradigms," Kevin W. Boyack and Richard Klavans, SciTech Strategies, Inc., from the "Atlas of Science," Visualizing What We Know, Katy Borner, MIT Press, 2010. This map is accessible online at: http://scimaps.org/maps/map/map_of_scientific_pa_55/).

2. We suggest that the consortium present the resulting research and visual map professionally, targeting a cross-disciplinary academic audience by supporting the presentation of papers at the widest possible array of conferences, with the goal of reaching professional meetings in all four areas of creative research (art, design, engineering, and science).

3. We suggest that the consortium present the resulting research and visual map publicly, targeting widely-read science and art publications and sophisticated general interest publications with images and analysis written for an informed general public.

4. We suggest that a cross-disciplinary symposium, co-sponsored by institutions recognized to be leaders in each of the four areas of creative research, be organized with sessions patterned on the content guidelines set out in this paper. The proposed symposium is envisioned not as business-as-usual, but as a meeting with a degree of "art" (surprises and challenges) in the form of the meeting. In critical theory terms, the meeting would be conceptualized as a "text" synthesizing research that is also in and of itself, a form of creative work and not simply a "report" on work that has already taken place. The overt goal of of the meeting would be to test and develop the guidelines and address the field mapping research; while the subtext would be to create meaningful, exploratory cross-disciplinary encounters.

* When space allowed, as in his posthumously published book *The Plenitude: Creativity, Innovation, and Making Stuff* (2007), Gold demonstrated the nuanced understanding of each domain he had developed as a contributor to all four areas.

** Here we use "agonist" in the sense developed by political theorist Chantal Mouffe. As scholar Nathaniel Tkacz writes in a gloss on Mouffe's work, "Whereas antagonisms can quickly spiral into violent conflict, *agonistic* relations involve a mutual respect for "the other", the recognition of and tolerance toward difference, and a perceived legitimacy in processes of mediation."

*** We acknowledge the irony of criticizing an approach as "formulaic" in a paper that is structured as a set of guidelines. We trust that our properly skeptical readers will take this proposal in an exploratory spirit.

Notes

1. At least this was the conclusion of the United Nations, which has sponsored the International Human Dimensions Programme on Global Environmental Change since 2006. http://www.ihdp.unu.edu/article/read/history [Accessed 10.25.12]
2. Biggs, Michael, Daniela Büchler, Simeon Nelson, "Social Dynamics of Knowledge Communication within Higher Education: The Case of an Art-Science Collaboration," uhra.herts.ac.uk, Jan 1, 2011, [http://www.academia.edu/948664/Social_dynamics_of_knowledge_communication_within_higher_education_the_case_of_an_artscience_collaboration] [Accessed 10.25.12]
3. Lattuca, Lisa R., *Creating Interdisciplinarity: Interdisciplinary Research and Teaching Among College and University Faculty, Vanderbilt University Press, Nashville, 2001, p. 137*
4. Examples of art-inflected events, conveying information but conducted with a meta-level of questioning and reflection, include the *Art as a Way of Knowing* symposium organized by Marina McDougall for the Exploratorium: http://www.exploratorium.edu/knowing/, events organized by artist collectives such as Platform in London [http://platformlondon.org/p-eventnew/t2/] and Stretcher in San Francisco [http://www.stretcher.org/projects/BAN/BAN_main.html], and performance lectures by figures such as artist Ryan Gander [http://www.artmuseum.pl/wydarzenie.php?id=Ryan_Gander_Loose_Associations_X_16_11_eng]
5. Elkins, James, *Why Art Cannot Be Taught: A Handbook for Art Students*, University of Illinois Press, Champaign, 2001, p. 6
6. The "3/4" figure is based on the list of artist participants in *ILLUMInations*, the central curated exhibition of the 54th Venice Biennale in 2011. At least 68 of the 82 artists draw on non-traditional art practices, although admittedly it is often difficult to assign firm categories. How, for example, would one classify Russian photographer Anya Titova, who creates interpersonal challenges such as asking strangers to touch her shoulder, in order to

photograph them? This might reasonably be classified as both performance and photography, although for purposes of this list Titova was counted for a singular discipline, photography.

7. van Damme, Wilfried [ed], *World Art Studies,* Valiz, Amsterdam, 2008, p. 27

8. Dissayanake, Ellen, *Homo Aestheticus, Where Art Comes From and Why*, University of Washington Press, Seattle, 1995, pp. 39-63

9. Historically the scientific construction of "race," for example, has been shadowed by cultural preconceptions. One example from the many papers and volumes addressing this issue is sociologist Margaret Hunter's paper Rethinking epistemology, methodology, and racism: or, is White sociology really dead?", *Race and Society 5* (No.2): 119-138

10. For example, Vito Acconci, who figures in art history as an influential performance and video artist, was named "Designer of the Year" at the 2012 Design Miami Fair. [http://www.thedailybeast.com/ articles/2012/10/24/vito-acconci-named-designer-of-the-year-by-design-miami.html] In the same year the work of the Brothers Quay (the collaborative cognomen of identical twins Stephen and Timothy), who for much of their career were known as illustrators, was accorded a major exhibition at the Museum of Modern Art in New York. [http://www.moma.org/visit/calendar/exhibitions/1240]

11. Edwin Hutchin's home page on the University of California, San Diego website http://hci.ucsd.edu/hutchins/

12. Lucy Suchman's home page on the Lancaster University website http://www.lancs.ac.uk/fass/sociology/profiles/Lucy-Suchman/

13. For a discussion of hacker ethics that originated in computer technology, see Steven Mizrach's essay "Is there a Hacker Ethic for 90s Hackers?" http://www2.fiu.edu/~mizrachs/hackethic.html [Accessed 10.25.12]

14. Among the works addressing this subject from different angles are psychologist Keith Sawyer's *Explaining Creativity: The Science of Human Innovation*, Oxford University Press, New York, 2006 and Larry Shiner's *The Invention of Art: A Cultural History*, University of Chicago Press, 2003

15. Bass, Thomas A., "Think Tanked," *Wired Magazine*, December, 1999 http://www.wired.com/wired/archive/7.12/interval.html [Accessed 10.25.12]

16. A range of research supporting this idea is reported at length in *Group Genius: The Creative Power of Collaboration*, R. Keith Sawyer, Basic Books, New York, 2007

17. Shaw, Benjamin G., "A Cognitive Account of Collective Emergence in Design," *C&C'09 Proceedings of the 2009 ACM SIGCHI Conference on Creativity and Cognition*, ACM, NY, 2009, pp. 59-68

18. Blast Theory website: http://www.blasttheory.co.uk/bt/index.php [Accessed 10.26.12]

19. Crutchfield, James P. and David D. Dunn, "Entomogenic Climate Change: Insect Bioacoustics and Future Forest Ecology," *Leonardo*, June 2009, Vol. 42, No. 3, Pages 239-244, Posted Online April 30, 2009., (doi:10.1162/leon.2009.42.3.239)

20. Ant Farm biography, Electronic Arts Intermix, http://www.eai.org/artistBio.htm?id=394 [Accessed 10.26.12]

21. Raqs Media Collective website: http://www.raqsmediacollective.net/

22. Videos of two installations by James Gimzeski and Victoria Vesna, an educational project Zero@wavefunction http://www.youtube.com/watch?v=_9bi-ExFzAs and an art Installation, Blue Morph http://www.youtube.com/watch?v=6YHo0aSLuZ8

23. M.G. Lord, *Astro Turf: The Private Life of Rocket Science*, Walker & Company, NY, 2005, p. 75

24. Julien Phalip, Ernest A. Edmonds, David Jean, "Supporting Remote Collaboration in Film Scoring," Proceedings of the 2009 ACM SIGCHI Conference on Creativity and Cognition, ACM, New York, 2009, p. 211-220

25. Leavitt, Harold, *Hot Groups: Seeding Them, Feeding Them, and Using Them to Ignite Your Organization*, Oxford University Press, New York, 1999

26. Sawyer was quoted by journalist Jonah Lehrer, "Groupthink", *New Yorker*, January 30, 2012, http://www.newyorker.com/reporting/2012/01/30/120130fa_fact_lehrer [Accessed 10.15.12]; While Lehrer's journalistic accuracy has since come into question Sawyer refers to a large body of studies supporting the statement in the book *Group Genius* (cited in note 19), including Diehl, lvI., & Stroebe, W. 1987. "Productivity Loss in Brainstorming Groups: Toward a Solution of a Riddle." *Journal of Personality and Social Psychology*, 53, 497-509, which includes a survey of 22 studies.

27. Jane Prophet and Mark d'Inverno, "Creative conflict in interdisciplinary collaboration: interpretation, scale and emergence," http://www.academia.edu/193448/e [Accessed 10.26.12]

Appendix: Summary of Coursework Guidelines

1. Communicate that categories of knowledge such as "fine art", "graphic design," "astrophysics", or "mechanical engineering" are themselves the collaborative creative productions of our society.

2. Convey a cultural overview that relates students' study of collaboration to contemporary conditions and the currents of change in all knowledge fields.

3. Offer participants an understanding of creative practice that relates their domains, acknowledging key points of similarity and difference, and considering the multi-dimensional factors involved in creative success.

4. Stimulate awareness of the models of "good science", "good art," "good design" and "good engineering" participants have in play through discussion of their aspirations (their values) and exemplars (best practices).

5. Build students' repertoire of decision-making models by presenting varied historical examples of cross-disciplinary collaboration.

6. Define project groups and give participants an active experience of working together, at whatever scale circumstances allow.

7. Ask participants to articulate in verbal or visual form the failures and successes of their work together by the standards of other group members, as they understand them, and exchange with the group regarding their conclusions.

Chaos, Computers, and Cyborgs. Developing the Art and Technology Practices in Taiwan

Coordinator: Yu-Chuan Tseng (Taiwan)

Antoanetta Ivanova (Australia/Taiwan)

Background

The history of Art & Technology practice in Taiwan can be traced back to the late 1970s when the first 'Laser Promotion Association' meeting was held in 1977. The aim of the event was to introduce laser art to Taiwan. It was a small, specialized field limited to research and development projects with no public outcome. At that time there were no cultural institutions, which would support the exhibition of such art. In 1988 the Taiwan Museum of Art (now National Taiwan Museum of Fine Arts) was inaugurated. One of its early exhibitions was 'High Technology Art' featuring Kinetic Art, Video Art, Laser Art, Computer Graphics and Cyber Art.

In 1990, upon returning from her studies in Japan, one of the most influential Taiwanese cyber artists, Peisuei Lee, staged the exhibition "Computer Art". In 1992 she published a book also titled *Computer Art*; a compendium of Peisuei Lee and Yoichiro Kawaguchi's computer artwork "Fractal". Through these seminal projects "computer art" was asserted as a legitimate term marking the emergence of the new media art form in Taiwan. Today, the broadly accepted term (in Chinese translation), which describes art and technology practices is: *digital art*, although *Art & Technology* and *new media* art are also used.

Academia

In the 1980s and 1990s there were no Art & Technology or computer art courses offered within the Fine Arts programs of universities. Around 1990 subjects such as Video Art, Installation Art and Multimedia Art were introduced but mainly focusing on video production and object installation. The early 1990s marks the emergence of the first wave of Taiwanese digital artists who, after having had opportunities to study abroad, returned to Taiwan with new ideas and methodologies that brought together art and digital technology. Many of these artists became university professors introducing new media art theory and practice at a tertiary level. The early courses in Computer Art were introduced within the various Schools of Design and Multimedia, with primary focus being on animation and computer games design, with some academics making individual efforts to broaden the curricular into digital art.

Since, three key Art & Technology programs that have been established at Taiwanese universities. In 1992 the Center for Art and Technology was founded at the Taipei National University of the Arts (TNUA). It is the first university research center solely dedicated to exploring the potential and innovative aspects of digital art. The center has three laboratories: Tangible Interface Lab; Trans-Sonic Lab, and Trans-disciplinary Media Lab.

In 2001, TNUA founded its Graduate School of Art and Technology, which was transformed in 2010 into a Department of New Media Art offering undergraduate courses in new media art theory and practice. Some of the most renowned established and emerging Taiwanese artists are graduates of this program.

The National Taiwan University of Art (NTUA) hosts the Digital Art Lab, established in 2001 as part of its Department of Multimedia and Animation Arts. The program comprises of research courses, exhibitions, seminars and international exchanges through which students are encouraged to push the boundaries of Art & Technology research. Through the application of digital moving image production and postproduction technoques, interactive installations and digital performances, new experimental and cross-disciplinary works are developed. The Graduate School offers digital art courses both in theory and practice. The students of both of TNUA and NTUA have become the backbone of the activities of Taiwan's digital art society.

In 2001 Chun-Tung University established a PhD program with its research focusing on digital art theory and practice. In 2006 the interdisciplinary group 'TransArt' was founded by senior academics from the Institute of Applied Arts, Institute of Music and Institute of Architectures. The group run a 'New Media Experimental Practice' course offering students the opportunity to work on tarns-disciplinary performance projects. The idea was to not only encourage the creation of such works, but also to allow students to take part in a process of particiantion, and in doing so learn through observation and exprimentation.

Art & Science research

The Graduate School of Art and Technology at TNUA is the first academic program dedicated to technology art. With an engineering background, its inaugural director Xiaoniu Suchu Hsu (also director, Center of Art and Technology 2005-2009) became the first engineer-academic to cross into the humanities through the introduction of technology-driven art research and practice. This enabled the school to bid for funding from the National Science Council, with most of the projects in the program being in the field of Future/Digital Museum, Digital Archive, Innovation Technology Development in Digital Life, and Creative Space. The pioneering program comprised of studies in engineering, technology art, and animation, according students the opportunity to gain conceptual and practical skills in both engineering and art. Students completing the course had to learn mechanical engineering, software programming and interaction design as part of their arts curricular. Even so, there was no science or technology research facility involved.

Taiwan's Chun-Tung University focuses on the development of science and engineering. One of the digital art pioneers at the university has been Tien-Chun Cheng, who consistently has tried to encourage collaborations between the Arts and the College of Electrical and Computer Engineering but never succeeded.

In Taiwan, it is a popularly held view that significant qualifications are those leading to better business opportunities or entry into civil service. To prepare for university entrance exams high school students need to focus on subjects such as Math, Physics and English. The pressure to do

well at such subjects—in order to be accepted into competitive university degrees—has had a negative effect on students' general interest in the arts.

Because the value of an engineering or science degrees is held in a higher regard than the arts, Art and Science remain in two separate domains with no tangible crossovers, be it at an academic or art practice level. The practice of Art & Science collaboration is not understood in Taiwan. Generally artists and engineers follow traditional lines of delineation between the two disciplines. Any team attempting to develop Art & Science projects will have no guidance as to how to harness the knowledge practitioners from each discipline bring into the mix, and true collaboration will not be realized. The outcome of such collaborations remains to be art-driven, which means that the engineers' skills are regarded as being subservient to the artistic process, and science or technology collaborators are not credited as legitimate co-creators of art projects.

Museums and Galleries

Some of the milestones in the development of the Art & Technology field of contemporary art practice in Taiwan include the 2004 exhibition 'NAVIGATOR: Digital Art in the Making', realized under the auspice of the Cultural and Creative Industries Development Plan's, Digital Art Promotion Program of the Council for Cultural Affairs, Executive Yuan of Taiwan (now Ministry of Culture). The exhibition introduced trends in Western digital art, showcasing the integration of digital technology and art. International artist included Art+Com (Germany), Blast Theory (UK), Ross Cooper (UK), Jussi Ängeslevä (Finland), Jodi (Netherlands+ Belgium/Spain), Josh On (Netherlands/USA), Golan Levin (USA), Rafael Lozano-Hemmer (Mexico/Canada), Christian Möller (Germany/USA), Christa Sommerer; Laurent Mignonneau (Austria), amongst others. The artists also participated in public forums in order to share their professional experiences and insights.

In 2006 the 'Digital Art Festival Taipei' was established. It is an annual event featuring international and Taiwanese digital artists; comprising of an international exhibition, awards in Digital Art, Digital Art Performance, Digital Art Criticism and K.T. Creativity (student competition), digital art workshop, artist-in-residence exhibition, and an animation program. The focus of the program is on trans-disciplinary Art & Technology practices. The Digital Art Festival is managed by the Digital Art Foundation, which since 2006 also oversees the activities of the Digital Art Center. The Centre's mission is to nurture the development of emerging Taiwanese artists, and harness cross-platform and cross-regional cooperation.

In 2011 TNUA hosted 'Transjourney, Future Media Festival', which is envisioned to become an annual, large-scale event showcasing local achievements in integrating art and technology. It is sponsor by the Ministry of Education under its 'University Teaching Excellence Program'. More than 40 digital artists and groups, from Taiwan and abroad, participated in the first iteration. Its three themes are: present exemplary Taiwanese art projects in interactive art, cybrog sculpture, digital performance, sound art and video art; showcase pioneering international artists such as Nam June Paik and Herman Kolgen, and also display the research achievements of the Center of Art and Technology.

Championed by a handful of private gallery owners, new media art was introduced at the 2009 and 2010 Art Taipei art fairs through a series of specially curated exhibitions; and at the Art Taipei Art Market Forum through presentations by international guest speakers discussing Asian New Media Art and trends considering the sector. Currently there is a small number of pioneering private galleries working hard to introduce video and digital media art to private collectors. Compared to trade in contemporary visual art, the private and corporate collecting of digital art, including video art, in Taiwan is in its early stages of development.

Public Funding

The 2004 'NAVIGATOR: Digital Art in the Making' not only stimulated local discussions on digital art within academic and creative circles, but it also captured the attention of senior politicians and policy makers within the highest levels of government. Today the Ministry of Culture and the National Culture and Arts Foundation provide grants for the creation and dissemination of Taiwanese Art & Technology projects. The 'Techno Art Creation Project' funding scheme of The National Culture and Arts Foundation was available between 2005-2007. A grant of 500,000 NTD was awarded on a competitive basis. A total of 18 projects were produced, which subsequently were toured around Taiwan.

The 'Techno Art Creation Project' was the first of its kind grant in Taiwan that provided artists with substantial support to create ambitious, large scale digital media artworks. Most of the artists who participated in the scheme continue to be active practitioners in Taiwan. Since 2010 until now, The Ministry of Culture of Taiwan also provided new work development grants for digital art and digital performance art. Under the 'Government Cultural Policy' the main objective of this funding has been to promote the development and appreciation of digital art while supporting distinct Taiwanese digital art practices. A total of 34 trans-disciplinary performance projects have been produced as a result.

In a further attempt to stimulate the development of the sector, since 2010 the Digital Performing Arts Festival is staged as annual event organized by The Ministry of Culture of Taiwan. This year audiences had the opportunity to experience to a wide variety of digital work by local and international performing groups.

Future Directions and Suggested Action

There is now a third generation of Taiwan artists working with digital media. They are becoming increasingly sophisticated as well as diverse in their approach to Art & Technology practices. However, if the energy and innovation of Taiwan's media art practitioners is to be sustained, a consolidated cultural policy at government level needs to be developed and implemented. The current policy ecology of the art industry in Taiwan is not sufficient to support the digital arts move into the mainstream of contemporary culture. It is a chaotic environment with occasional outbursts of energy and big project outcomes visible to the public at various museums and venues.

Even though there are grants from different government departments and private foundations digital art is not consistently supported and the digital arts sector is not seen to be operating as an

industry that should attract greater investment for further development. As of 2009 the Taiwanese government is focusing on the Cultural and Creative Industries as an area of economic development, with most of the investment going into manufacturing and design, and cultural recreation and tourism.

In the preface of the 'Transjourney, Future Media Festival' exhibition catalogue, the ministers from the Ministry of Education, Council for Cultural Affairs and National Science Council jointly state that the development of the Taiwanese Culture and Creative Industry is of a primary policy agenda. The integration of Art and Technology is seen as one of the drivers that can elevate Taiwan's economic development.

Museums do not proactively commission, exhibit, collect and provide public forums that encourage the appreciation and display of Taiwanese digital art. Most of the influential Taiwanese Fine Art curators overseeing museum programs maintain a skeptical view of digital art. Museums rarely engage expert curators who have the depth and breath of knowledge required to develop critical exhibitions and thematic discourse on a diverse range of new media art topics, and who can develop education programs for different sections of the public. There is also no sufficient curatorial understanding of the technological aspects concerning the installation and presentation of digital art. Media art exhibitions remain more as one-off showcase events than an on-going commitment on behalf of the Museum industry to introduce digital art to the public. At the tertiary level, increasingly digital art is becoming intertwined with design, which impoverishes the art industry as pure research and pure art-practice become subservient to commercial outcomes.

For the Taiwanese digital arts to become established as a legitimate contributor to contemporary culture the above, and other, issues are to be addressed through peer review, policy development, and the establishment of cohesive linkages between artists, academic institutions, research centres, private galleries, museums and civil services. These local challenges are not dissimilar to other parts of the world where this field of art practice is developing.

Process Driven Potentials for Interdisciplinary Learning: Ubeats, a Model for Science and Music Learning

Coordinators: Cynthia L. Wagoner, Ph.D., East Carolina University, and Robin Wilkins, PhD student in Neuroscience of Music, The University of North Carolina Greensboro

ABSTRACT

National policy makers, economic stake-holders, and learning advocacy professionals recognize the critical importance for young minds to develop as scientifically grounded, yet cognitively flexible. Creativity, the mind's ability to link previously unconnected and often disparate concepts into a useful idea, is now recognized as inherently linked to interdisciplinary situational learning. The challenge for the arts and sciences is to reevaluate their inter-relationship and to explore collaborative new methods in investigative learning. The generation of new knowledge grounded in interdisciplinary concepts and methods is what will generate a co-created future led by scientists and artists. To achieve this goal, both the arts and sciences must reconsider traditional processes and methodologies that lead to curriculum-in-isolation. Disciplinary driven, yet artificial, barriers that unnecessarily prevent children from experiencing the potent and rich environment found within multi-modal and interdisciplinary learning must be challenged.

The next step in 21st Century learning is found at the intersection of arts and sciences. Whereas the science community seeks more ways to engage young students, the arts have often been able to easily engage students, yet without substantive inquiry. Finding a new model is the key. One example of a fully integrated interdisciplinary curriculum is UBEATS, a seamless science and music curriculum that utilize both science and music to provide creative problem solving activities and concept building. Using a BioMusic framework, both teachers and students benefit from interdisciplinary study.

Unfortunately, gaining ground in the elementary schools for such a curriculum has been relatively slow. Specific issues include but are not limited to: lack of contact time with students, resistance to teacher-to-teacher collaboration, and misinterpretation of in-service efforts. However, positive views of interdisciplinary, multimodal and inquiry-based learning must be cultivated simultaneously from the ground up and top down within the educational system. Overall, responding to pre-service teacher needs, receiving administrative and university support, and receiving funding are the current challenges to genuine interdisciplinary, multimodal curriculum.

National policy makers, economic stake-holders, and learning advocacy professionals recognize the critical importance for young minds to develop as scientifically grounded, yet cognitively flexible. The challenge for the arts and sciences is to reevaluate their inter-relationship and to explore collaboratively new ways of understanding the world. As schools address the broader meaning of literacy in the 21st Century, skills of problem solving and scientific-inquiry are being examined. The time is ripe for artists and scientists to lead the way in exploring interdisciplinary

concepts and methodologies. Grappling with a new paradigm of knowledge creation also challenges us to rethink traditional disciplinary relationships.

Current disciplinary driven barriers unnecessarily prevent and isolate young learning minds (children) from experiencing the potentially rich environment found within multi-modal and interdisciplinary learning. This is a challenge for researchers, educators, and policy makers. Infusing experiential inquiry-based learning within both the sciences and the arts is essential to the future of education. Using new ways of thinking about teaching and learning, we must generate meaningful and stimulating learning environments that enable young minds to generate cognitive flexibility, grow creatively, and to make connections about the world.

It has become more apparent than ever that the intersection of the arts and sciences provides fertile ground for 21st Century learning. Whereas science educators seek more ways to engage young minds through active participation in the arts, how to innovate such collaboration in effective, yet creative ways, has remained elusive. Concurrently, the arts, arguably the center of creativity and innovation, have often engaged participation without substantive understanding of inquiry. Finding a new model is the key. The Universal BioMusic Education Achievement Tier in Science (UBEATS) offers a specific model for the future in arts integration. UBEATS (see appendix A) was developed as a science and music curriculum package for elementary education in grades 2 and 5. The project was conceived to provide elementary classroom teachers with creative problem solving activities and concept building science and music lessons. Innovative modules were coordinated for upper and lower elementary grades, carefully aligned with both national and state science and music standards. The richness of the curriculum design is a model for collaborative work crossing disciplinary barriers to connect teachers to experts and virtual advisors from the fields of science and music. Such a model can lead the way for a new paradigm of interdisciplinarity in the classroom.

Two consecutive UBEATS Summer Institutes were held to launch and test the curriculum utilizing both classroom teachers and students in grades 2 through 5. Hosting a summer program provided classroom teachers with experiential opportunities with the curriculum, and allowed them to work side by side with students in the learning process. The culminating UBEATS curriculum project combines the subjects of music and science fluidly and the design allows users to encourage student-driven original thinking while simultaneously scaffolding new knowledge. Scientific skills are not sacrificed to do musical activities and musical skills are not diminished at the expense of scientific knowledge construction. The pilot summer programs allowed those involved the opportunity to observe the ways in which elementary children were responsive to the curriculum. Monitoring the effort of elementary-aged children and teachers as they studied side by side gave further depth to the project, as having teachers learning beside their elementary students created a co-learning model for teaching.

The emphasis on the ways in which music and science naturally intersect allowed students to raise relevant and practical questions and in turn created a focus on dynamic problem-solving activities, eliminating fragmented and disconnected learning. Students are able to approach given tasks with a focus on broader literacy skills of problem solving and scientific-inquiry. For example, throughout the week of camp, environmental sound artist Philip Blackburn set up musical environmental soundscapes for the children to experience, and assisted them in

investigating, researching, and creating their own music using similar methods while experiencing natural science concepts. Students investigated ways in which the natural world is musical through science-processing skills, building on the experiential nature of music and science. The lessons led them to become immersed in sound and the students were then able to articulate the principles of science in the world around them, all the while finding musical artistry through these same principles. The students carried the lessons from the classroom setting out into the field, behaving with curiosity as scientists, and formulated new ideas about their world.

Issues with Implementation and Suggestions for the Future

There is no doubt in our minds that the UBEATS curriculum model is a powerful example for the future of science and music teaching and learning. We must note that although the UBEATS curriculum has become available online during the past three years, teachers have not flocked to use the curriculum. Those teachers involved in the original camps and others who have gradually become aware of the availability of the curriculum, have been enthusiastic in adapting lessons for their own classrooms and the feedback positive. Downloads continue from the website on a weekly basis. We are left to ponder the following after two summers of work – why is such a dynamic science/music integrated curriculum, complete with virtual mentors and materials ready to use, not spreading like wildfire in our elementary schools? How do we create a tipping point for its use?

Indeed, issues reported incidentally to, during, or following implementation in classrooms appear to us as fairly consistent. First, elementary teachers express common concerns about lack of student contact time and the pressures of testing and school reform. The immediacy of these problems overtakes the support many teachers express for interdisciplinary approaches; therefore, it still isn't moving into the classroom. There is also what we might refer to as fatigue or exhaustion of the teaching profession. Teachers may want to be enthusiastic about new ideas, but as they are conscious of the politics of reform efforts and any packaged curriculum or in-service becomes 'one more demand' on their time in an already time-constrained school day. It may be a lack of time and energy, but it may also be a lack of money. Scientific inquiry and hands-on learning requires materials. In an economic era where many teachers may not have money for classroom supplies, spending out of their own pockets for specific curricular lessons is also problematic. More than one teacher informed us they altered the UBEATS curriculum and shortened lessons based on the materials they could afford to purchase, in combination with the limits of time in the classroom. Compounding the lack of funds, time, and energy, there are also fewer curriculum directors or administrative help available to teachers to find solutions to the problem of monies or time for specialized classroom activities.

There are also specific perspectives that keep classroom and music elementary teachers apart. Classroom teachers frequently have little time to interact with their 'specials' counterparts. Any time their classroom has moved into music, art, or dance classes, the classroom teacher has preparations to manage. Perhaps more importantly, classroom teachers indicated they were insecure with the language of music itself and felt incapable of interacting with the elements of music within their lessons. Indeed, it remains that one cannot begin to integrate the arts unless you speak the language of the art itself. Efforts were made to conceptualize and assist the

teachers in the weeklong UBEATS seminars, but some teachers remained unconvinced they could do so on their own, without music teacher assistance.

As musicians ourselves, we must acknowledge what we find as the musician/artist perspective of interdisciplinary programs. Interdisciplinary studies easily generate apprehension for current reformation due to the historically wearisome efforts to marginalize or otherwise 'do away with the arts,' and specifically music. Having suffered through countless budget cutbacks, personnel scares and other 'attacks' on music, musicians and teachers of music are repelled by the notion that their discipline should require outside influences or integration with subjects such as science to exist within the public schools. Though many Arts educators are savvy enough to advocate their subject area as a way by which to know the world, they also recognize that there are specific ways in which musical knowledge might be diminished in attempts at integration.

Beyond that fear, integration of music has generally consisted of limited activities, such as playing Mozart during quiet periods or singing songs about the life cycle of frogs. With a poor record of classroom teacher attempts to integrate with a depth of musical literacy it is understandable that music educators would shudder to see anyone suggest another integration project using music. They need to be convinced that collaboration will strengthen musical objectives and enrich the learning process, not diminish musical learning. Music teachers, twice burned, have a right to be sensitive to the issues of integration. Without knowledgeable administrators, those in charge of hiring may misinterpret collaborative efforts as a way to teach music solely through other subject areas, eliminating the need for music educators, and removing music education completely from the elementary day (Veblen & Elliott, 2000).

UBEATS was presented as a team-taught curriculum, with the music teacher teaching alongside a classroom teacher. A collaboration of minds from both musicians and scientists and those who consider themselves both will not happen without a paradigm shift within elementary education. Effective collaborations take time. And the need for time doubles us back to one of the first issues for our teachers: a concern for time to actually arrange collaborations, plan for deep, thoughtful integration of the subjects, and to execute such plans.

Previously, we alluded to attitudes and understanding of integration extending to the ways in which pre-service teachers learn to teach. Modeling is the most powerful way to influence young teachers. That said it is difficult to model interdisciplinary collaborative teaching at the university level. The structure of many colleges and universities do not support or reward interdisciplinary studies. University professors suffer from some of the same problems that elementary teachers face, if not for slightly different reasons. For example, those of us who teach the 'special' areas, such as the arts, outside of the school of education frequently must advocate for integration within the confines of a one-semester class in which we also must introduce skills of one specific art. Research has indicated that overall, arts courses such as these do not encourage artistic language in integrated activities in pre-service teachers. Only if pre-service teachers have had positive artistic experiences in the public schools before arriving at the university does the experience in such courses become significant (Hash, 2010). In the current climate of education cuts to K-12 arts, this does not bode well for future artistic integration in the elementary classroom.

Without a collaborative environment at the university level, it is an uphill battle to introduce an honest integrated and collaborative program. Modeling examples are left to the semester of student teaching for pre-service teachers. Mentor teachers need to model integrated, inquiry-based, multimodal instruction for the student teacher in the classroom setting. Teacher modeling won't happen until administrators encourage and support curricular programs such as UBEATS. The stalemate of who will lead the change in the cycle of classroom practice is thus perpetuated.

Addressing Change into Action

As we have stated, the resistance to a powerful, revitalized multi-modal, inquiry-based curriculum is complex and deep. The problem is not as simple as developing the curriculum itself – the complexity must be attacked at several different levels and at the same time. As seen in our own research and across the literature, challenges include 1) Addressing pre-service teacher education (allowing for modeling and broad changes at the university and college level, sustained through student teaching), 2) Offering in-service training for teachers and more vitally for administrators (those who control purse strings, scheduling of students, etc.), 3) Developing a research base on multi-modal, inquiry-based learning, and 4) Political (combatting the stalemate in educational funding tied to testing). These broad challenges may be approached through such vehicles as the Network for Science, Engineering, Art, and Design (SEAD) network, allowing cross-pollination to occur across a variety of disciplines and various stakeholders in order to raise awareness and spur local and regional change.

Pre-service Teacher Training

Pre-service teacher training must allow the next generation of teachers opportunities to begin to examine what interdisciplinary studies truly are and what that might mean for their practice. There is much for them to learn and we are short on time as it is. For example, how does one go about creating meaningful integrated experiences for a future classroom when one is not an expert in every field? Preparing teachers for a non-traditional approach must include such topics as collaborative teaching, assessment and curriculum design, teaching to topics, issues, places, and problems rather than using one textbook or focusing on skill-based learning alone (Campbell & Henning, 2010). This will necessitate more detailed work at the university and college level to alter current teaching practices, and create an environment within the School of Education that leads change rather than reacting to it.

In-service Training for Teachers and Administrators

In-service training, such as UBEATS summer camp, must also become a foundational center of the University landscape. Finances aside, greater efforts need to be made to reach out to schools and bring collaborative, integrative discussions to the schools. Teaching through using a model curriculum may be the first step. Having the opportunity to present a tangible program and lay out the support, time, and financial needs first to administrators may help smooth the road for the teachers. However, this should not appear as a mandate for teachers. Working side-by-side then with the teachers who are initially interested in the new program, we hope to connect the process with our pre-service teachers. Pre-service teachers might assist in modeling lessons in in-service

settings, involving music and elementary classrooms as part of our university training experience.

Develop a Deep Research Base on Multi-modal, Inquiry-based Learning

One of the other issues we see is that the research base has yet to form a criterion-based measure for interdisciplinary studies. One might argue that isn't needed. However, we need to understand how children learn best using research methods focused on a child perspective, not an adult perspective. Uncovering how children benefit from learning through integrative, multimodal, inquiry-based models of instruction are necessary, though difficult. Research to date has not given us ammunition in this age of accountability concerned with illuminating gains in test scores. Though important case studies are being done, such as those through Drew Charter School, Exploratorium, Rhode Island School of Design Foundation Studies, Blue School, and Ximedica, there is much work to be done (http://stemtosteam.org). The perplexing dilemma is surviving a political climate that values criterion-based measures alone as an indicator of learning. The curious mind is at stake. Finding some way to quantify the strength of inquiry-based learning, or provide evidence that approaches toward teaching and learning must change for the economic and political health of our country, is paramount today.

What we should be looking for are the points at which teaching and learning in interdisciplinary work involving the arts and the political pressures teachers are facing are at odds. Furthermore some research indicates effective schools are populated by teachers who provide integrated instruction, blending workplace readiness skills into subject areas, and throughout the curriculum whenever possible (Stoll & Fink, 1996). Critics of interdisciplinary studies voice that the depth of subject matter and sequencing of important skills are somehow shortchanged in order to find ways to combine two subject areas (Ellis & Fouts, 2001; Sowell, 1995). The research base should be expanded to include well-designed studies to examine the ways in which integration is most effective in both short and long term benefits for children.

Political Issues tied to Education Funding

Universities find themselves fighting for survival at the time when public schools need their help the most. We must be politically active and vigilant about funding for our schools. It is a little thing to think about all science and music UBEATS projects costing one classroom a total of $350, but that is a huge amount to ask teachers to spend out of their own pockets. However, finding the right time to hit hard for funding to provide easily accessible interdisciplinary, multimodal curricula in all schools remains elusive in the current economic climate.

Challenges and Suggested Actions

Envisioning the learning environment as genuinely interdisciplinary with a multimodal curriculum, providing true situational learning means eschewing teacher-dominant connections. The arts, and in particular the science of BioMusic, can greatly enhance and reinforce student-driven knowledge while simultaneously enhancing the mind toward natural creativity, intuition substantiated with knowledge, and lead education in a much desired direction, in spite of challenges.

Challenge 1: Pre-service teacher education does not include interdisciplinary examples of multi-modal curriculum with learner dominant connections. (Stakeholders: University administrators, university faculty)

Suggested Action: Programs must be promoted at the university level to encourage tenure and promotion guidelines to encourage collaborative cross-curricular partnerships. Administrators must be willing to make promotion and tenure guidelines include such cross-curricular partnerships to encourage educators across the university to collaborate. In turn, the artists, designers, humanities, scientists and educators at this level can be encouraged and rewarded for efforts to design new ways of addressing interdisciplinary studies.

Challenge Two: In-service training is sporadic at best and leaves teachers to implement new ideas without help. (Stakeholders: K-12 Administrators and school teachers)
Suggested Action: In-service training for teachers generally starts at an administrative level, as school administrators are frequently in charge of both in-service workshops. As such, administrators are in need of in-service workshops to focus on their role in selecting pedagogical ideas that might encourage change within their school's classrooms. In-service efforts must begin with the administration at the same time as teachers and continue as a partnership effort to effect change. In-service connections to the university should be forged as per challenge one.

Challenge Three: Without a paradigm shift, collaborative teaching for integrated multi-modal inquiry-based learning is lost. (Stakeholders: University faculty, K-12 administrators and faculty, Pre-service teachers.)

Suggested Action: Schools of Education and Arts Educators must support the suggested actions of the first two challenges by modeling collaborative teaching, encouraging collaborative teaching, and assisting in finding the ways collaborative teaching can exist within the brick and mortar of the public schools with administration. A dialogue between administrators, teachers, and higher education specialists needs to begin on rethinking the silo mentality as it has seeped into the public school system.
Challenge Four: Research on multi-modal inquiry-based learning is limited. (Stakeholders: University Researchers, Educational Researchers, Foundations and Government Agencies)

Suggested Broad Action: Foundations and Government Agencies need to invest in research to inform the ways in which creativity and cognitive flexibility can be defined and investigated through multimodal inquiry-based curriculum in real time with children in a classroom. Financial support for research speaking to long-range effects of interdisciplinary instruction and collaborative teaching is needed. We need brain research and educational research to collaborate on how to promote effective educational reform for the sciences and arts. In-service connections must be forged to research, and shared with practitioners and political stakeholders in challenges two and four.

Challenge Five: Political stalemates and punitive measures that tie educational funding to testing limit the ways in which needed reform measures can take place. (Stakeholders: Researchers across interested parties, Government and Educational Foundation/Agencies)

Suggested Action: Create a collaborative forum to allow collaboration of researchers in brain science, SEAD, STEM, and other educational outlets to share ideas and create a lobbying unit for educational change. This is tied directly back to the first three challenges. We have to address all these areas from every level at the same time to find the tipping point for change.

Appendix A

UBEATS acknowledgements

UBEATS, a project by UNC-Greensboro (UNCG), North Carolina State University (NCSU), and the National Science foundation, was developed as a curriculum package for elementary education in grades 2 and 5. Under the leadership of Patricia Gray and David Teachout from UNCG, and Sarah Carrier and Eric Wiebe from NCSU, two teams of in-service science and music teachers (Ms. Christen Blanton, Carmen Eby, Debra Hall, Crystal Patillo, and Cathy Scott) created the curriculum included online at http://performingarts.uncg.edu/music-research-institute/research-areas/biomusic/ubeats.
Virtual Mentors on the UBEATS project include Roger Payne (whale songs) Ocean Alliance; Steve Nowicki (bird songs) Duke University; Don Hodges (music/brain) University of North Carolina Greensboro; and Doug Quin (bioacoustics) Syracuse University; and Tecumseh Fitch (animal communication), University of Vienna.

References

Campbell, Cynthia, & Henning, Mary Beth/ "Planning, Teaching, and Assessing Elementary Interdisciplinary Curriculum." International Journal of Teaching & Learning in Higher Education 22, no. 2 (2010): 179-186.

Ellis, Arthur K. & Fouts, Jeffrey T. "Interdisciplinary Curriculum: The Research Base." Music Educators Journal, (2001): 22-26, 86.

Hash, Phillip M. "Preservice Classroom Teachers' Attitudes Toward Music in the Elementary Curriculum." Journal of Music Teacher Education, 19 no. 2 (2010): 6-24.

Sowell, Thomas. The Vision of the Anointed. York: Basic Books, 1995. Print.

Stoll, Louise and Fink, Dean. Changing Our Schools: Linking School Effectiveness and School Improvement. Open University Press, Buckingham, 1995. Print.

Veblen, Karl K. & Elliott, David J. "Integration: For or against?" General Music Today 14, no. 1 (2000): 4-8.

A Study of Art/ Science Collaboration in China and Hong Kong

Coordinator: Annie Wan

Scientific inventions of Ancient China are immensely important to our global culture and everyday life, while traditional artworks (paintings and sculptures) possess a long history in China. In this time of economic boom in China, science finally meets arts in various ways, such as usage of fireworks and gunpowder in Cai Guo Qiang's works, interactive art by Feng Mengbo, etc. This paper describes the historical background of Chinese art/ science collaboration. In addition, it outlines the current development of art/ science collaboration in China, analyzes differences and similarities between practices in China and that in Western countries. It also investigates their definitions of technologically-assisted art and potential problems in art/ science collaboration. Lastly, it foresees how to extend the boundaries of current art/ science collaboration practice, suggests both possible conceptual and technological developments to artists/ engineers and academia.

SUGGESTED ACTIONS

For Educators and Academic Administrators

1. Support collaborations among scientists, artists, designers and also experts from the industries. More and more art/ science and media arts labs were established in recent 5 to 10 years, they are mostly linked with famous and traditional universities such as Tsinghua University and Beijing University in China. These labs focus on technologies such as augmented reality, high-end 3D animation, wearable technologies, etc. However, projects and artworks they developed are mainly based on technologies invented by western countries/ adopted by many artists before. As a 'world factory', China has a lot of industries, ranged from heavy industry to nanomaterial manufacturing. Artist Feng Mengbo's Eye Chart is a great example of this kind. He collaborated with Founder Electronics Co., Ltd. and created 2 new chinese fonts. As a consequence, universities are encouraged to work with industries and work as inventors of new technologies.

2. Allocating resources not only researches on technological development but also contextual and cultural development of technologies anticipated. Most of the labs focus on usage of new media technologies and development of courses that offer training on animations, virtual reality, such as Department of Digital Art and Design in Beijing University. While most of the arts/ science labs are developing new media projects, no other organizations is investigating cultural impacts of their projects and its contextual background. Hence, data, either quantitative or qualitative of these arts/ science projects should be analyzed. These researches may focus on issues of their cultural impacts, such as how these technologies affects modes of living especially in Chinese societies, etc.

3. Work with the government funded organizations and other universities. China Art Science and Technology Institute (CASTI) is a government funded organization and it is a hub for arts/

science technological researches. Universities in China organize conferences, exhibitions and invite international artists all over the world since 1990s. But they barely work among universities or collaborate with government organizations. Universities should work with the government organizations, such as CASTI as well as other universities. Work/ interested areas of some labs in universities are overlapped, they concern about technological usages on art. Collaboration among these labs will eventually create true transdisciplinary studies of arts, design, humanities and sciences, enhance diversity in research and education.

For Government Agencies and Other Funders

4. Scholarships and financial aid schemes for undergraduate students, graduate students, artists and scientists to study aboard.

Learning Across Cultures

Coordinators: Roy Williams, Jenny Mackness, Simone Gumtau

Abstract

Education is built on the foundations of peer reviewed knowledge, first formalised in the Royal Society many years ago, so networking is nothing new. What is new is the facility for networking across the internet. It is now so much easier to 'explore tools, information, resources and points of view from other disciplines that can elucidate and even answer problems'.

This provides opportunities and challenges for the curriculum. Institutions, through their courses, and students and staff through their networked learning and research, are all trying to find ways to reconcile core curriculum values and standards with these rich, serendipitous, and sometimes centrifugal, forces, which are becoming core to the dynamics of the new global political economy (1).

We have identified a number of new types of open, and in principle trans-disciplinary curricula: massive open online courses (MOOCs), interactive spaces (MEDIATE), trans-disciplinary installations (The Brain) – as well as resonances with much earlier curricula innovations, in Montessori education.

We propose new methodologies and approaches that may help us to describe, evaluate, manage and design these new dynamic curricula, based on recently published research, in *Footprints of Emergence* (2). To do justice to these dynamic changes, we developed a new learning topography – a 3D graphics 'footprint' template which acknowledges and integrates open or emergent learning as well as *prescribed* learning (or core knowledge). The framework is applied to a range of learning events.

1. Introduction

Curricula that include science, engineering, art and design can be rich, stimulating and creative. They can also be frustrating and discordant – both in the design process and in implementation. These unique opportunities and challenges are consequences of working across not just different disciplines, but often different cultures. In other words, not just different ways of thinking or writing, but different ways of being – being part of social, intellectual and professional communities. It is from this perspective that we will explore the issues in this White Paper, which could be titled *Learning (and working) across Cultures.*

There are many ways to approach learning across cultures. This paper explores the particular role that emergent learning can play in developing new ways to design and implement learning across cultures, based on our recent research into emergent learning, and the affordances of

social media. *Emergent* learning is in principle adaptive, ordered-and-yet-unpredictable, and flourishes in curricula that are themselves emergent. A more formal definition is:

> *Emergent learning* is likely to occur when many self-organising agents interact frequently and openly, with considerable degrees of freedom, but within specific constraints; no individual can see the whole picture; and agents and system co-evolve (3).

The key to designing for emergent learning is to define negative constraints, not positive outcomes – which turns traditional curriculum design on its head. And if you want an example of emergence, Twitter is almost a caricature, although how much people actually learn in Twitter is moot. It could be argued of course that the negative constraints of Twitter, and their governance, are still in the process of being established.

There are two contributions that this paper can make to SEAD: on the one hand, a practical framework for describing, designing, and managing emergent learning in general; and on the other hand, some specific examples of how this can be applied to SEAD and related contexts. We gain rich insights from *emergent learning,* but it is always somewhat creative, surprising and unpredictable; hindsight does not necessarily produce foresight. Consequently, emergent learning does not produce *best practice,* but rather, *interesting and thought provoking practice.*

This will lead to a somewhat different and innovative set of 'suggested actions', to contribute to the task of developing SEAD curricula, and to contribute to the development of the notion of the curriculum itself, which might usefully accommodate more emergent teaching and learning, and even some emergent curricula, for 'learning across cultures'.

2. Current State of Practice

It is ironic that the management of education has become more closed while learning has become more open, particularly over the past 10-20 years. The curriculum has become more instrumental, predictive, standardized and micro-managed, in the belief that this supports employability and learning. Meanwhile, people have embraced open, interactive, participatory, collaborative and innovative networks for living and learning.

There is some progress, however. Increasingly, a range of people and institutions are convening and curating open forums - both online, in MOOCs, JAMs, Online forums, not to mention blogs, twitter clouds, and wikis, as well as face-2-face (f-2-f), in *un-conferences*, and exhibitions and interactive installations that are curated across traditional disciplines. Both online and f-2-f events constrain or enhance participation in their own ways: online events can easily be opened up to global participation in ways that f-2-f events cannot match, and f-2-f events can provide an immediacy and richness that online events cannot emulate. These distinctions are, of course, becoming increasingly blurred, as the internet becomes just an ordinary part of people's lives.

MOOCs – (Massive, globally Open - and generally free - Online Courses) in particular are growing apace, and diversifying in size (ranging from a hundred to many thousands of participants), in facilitation (ranging from active facilitation and moderation to aggregation, to

machine managed), in pedagogy (from connnectivist and constructivist, to behaviourist or instructivist) and in content (from open to proprietary, with an emphasis on open,, or at least *creative commons* resources).

But they all rely on peer collaboration across a range of social media, and active, self-organised participants. And MOOCs seem to have split, already, into cMOOCs - with more emphasis on constructivist teaching and learning- and xMOOCs – with more emphasis on behaviourism and numbers - of 'raw' enrolments rather than retention, and throughput rather than accreditation, (4). There are also, now, what might be called mMOOCs – 'machine MOOCs' which could be seen as DIY-book clubs with self-organised study groups. Formal assessment and accreditation is often an optional add-on, though it is unlikely to be free – if anything, it is likely to be the revenue generating tail that finances the 'free' course – which has to be financed somehow. This opens up the curriculum, in principle, to flexible and open access on the one hand, but also to a potential undertow of marketization and commodification of teaching and faculty on the other. It does at least allow the student to opt for either an informal, free, 'certificate of attendance' – or for certified, formal assessment – at a cost. But the age-old adage "there's no such thing as a free lunch" should always be kept in mind.

3. The Potential

Working across disciplines can lead to creative and innovative solutions to problems – particularly intractable ones. This has potential value for society and for the participants. It also has potential value for specific disciplines, by enhancing creative approaches within those disciplines – whether arts or sciences.

However, we need to keep in mind that this requires a willingness to work across not only epistemologies, but also social, disciplinary and institutional cultures. For example, the physical sciences, in which things are expected to behave predictably, are a different culture compared to the social and biological sciences, in which organisms and people are self-organised, and consequently behave adaptively, somewhat unpredictably and, in the case of fine arts and performance arts, are required to be creative and innovative.

In addition, learning across cultures requires you to work across different types of texts and media – from the formalised, reified written texts typical of the sciences, to potentially more open, flexible and metaphorical texts - typical of the arts and humanities. These different perspectives have implications for people's social and professional practice and identity, as well as for their commitments to their social and professional cultures. The key question is not "what do you want to learn when you grow up?" but rather "what do you want to be?" And the answer is generally not expected to be "both."

One of the ways to work across these different perspectives and cultures is to convene open courses, networks, or discussions which encourage emergent learning, and to find topics (for instance: water, energy, habitat, learning, the brain, micro-credit, HIV-AIDS) which can attract contributions from a range of disciplines and perspectives. Such events can be open to ideas, disciplines and perspectives, as well as to diverse experiences, ages, cultures, and languages.

4. Describing Emergent Learning

In our research we identified a range of examples of emergent learning, and developed a new framework to capture and map out 25 relevant factors, as well as the dynamics of change in these factors over the course of a learning event. This framework, *Footprints of Emergence*, takes the form of a 3D typography or landscape - see (2) for details. It is based on complex adaptive systems theory – see (3) for the details. Below, in "Figure 12", is an example of the way *CCK08* (the Connectivism and   Connective Knowledge course in 2008, the first global MOOC) was described using the Footprints of Emergence, as it changed from the initial *design* phase across over 4 subsequent phases.
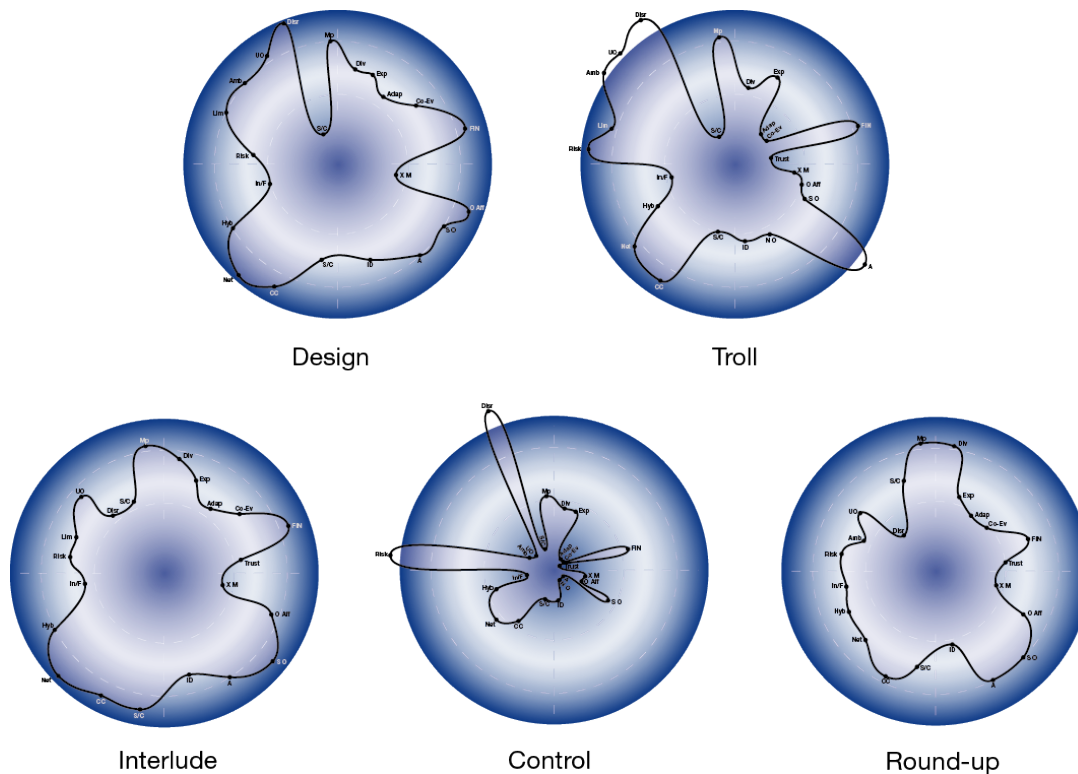
Figure 1. The design and four subsequent phases of CCK08.
From: Footprints of Emergence (2)

The footprints describe, and map out, the dynamics of learning across a learning event (such as CCK08, above). They map out the way learning has been designed, delivered, and responded to across a topography – a landscape of learning. This landscape includes prescribed learning (predictable, tightly specified outcomes) at the centre, and emergent learning across the 'top' or 'ridge' and towards the edge of 'chaos' (in complexity theory terms) This can be seen more clearly in cross section, in Figure 2, below.
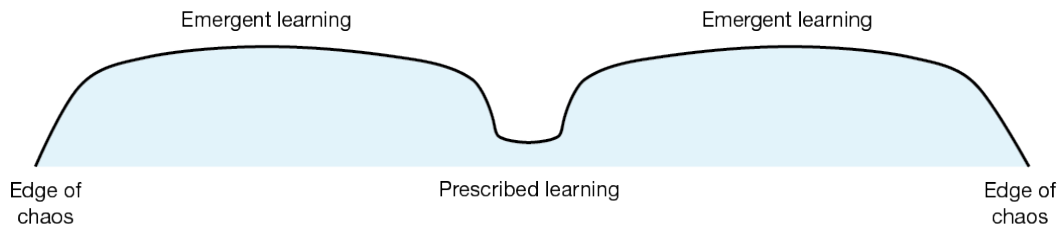
Figure 2. The topography of learning.
From: Footprints of Emergence (2)

The intention, here, is *not* to promote emergent learning, per se, as better or worse than prescribed learning, but rather to map out the dynamics of the way prescribed and emergent learning actually takes place in a learning event, to see whether that is *appropriate or 'fit' for a specific context*. In the *Footprints of Emergence* paper there are several examples of how the balance between emergent and prescribed learning is, or is not achieved, in different ways, for very different learning events.

5. Designing Emergent Curricula

The key to designing emergent learning and emergent curricula is to *define negative* constraints, *not positive outcomes*. The first step is to decide what degree of emergence is *appropriate* for a particular context.

If we take the example of CCK08, the convenors mapped out (explicitly or tacitly) the degree of constraint, or lack of it, of their four factors: *connectivity, autonomy, openness* and *diversity*. As participant-researchers, working with our research respondents, we found that we needed to tease out and elaborate those 4 factors into, eventually, 25 factors. What we would describe as the *de facto* (design) constraints, at five points in the event, are mapped out in the five footprints, above.

These 25 factors are 'scored' (on a relational, continuous scale, not a discrete scale). A high score indicates very little constraint, and places the factor 'near the edge of chaos' (and the footprint). A very high score indicates no constraints at all, which places the factor 'over the edge', potentially into complete disorder. A low score places the factor towards the centre, and right at the centre the constraints are extensive enough for the outcomes to be prescribed as positive, i.e. with no flexibility or room for emergence at all.

In this way the footprints can be used to design curricula that have varying degrees of emergence and prescription. The footprints can be used retrospectively, to describe the implicit (or tacit) design as it was operationalized, and experienced, at that time by a particular group of stakeholders (researchers, participants, convenors, teachers, etc.) Many educational events respond and adapt to their unfolding context in some measure, in which case the dynamics of the (implicit) design will change, and a series of footprints will need to be drawn (see Figure 1).

The design parameters vary from emergent - towards the edge (defined by negative constraint) to prescriptive - towards the centre (defined effectively by so many negative constraints that it makes more sense to define them as narrowly-specified positive outcomes). Within the design

process, and within the management of a course, this 'tipping point' always needs to kept in mind.

The same applies to learners, or participants. They may need to be guided, or invited, to explore learning in more or less adventurous and creative ways, depending not only on the aims and purpose of the curriculum and the course, but often more importantly on the participants themselves – their degree of comfort, fear, confidence, experience, and their intentions and aims for their learning too.

6. Suggested Actions

Introduction

There must be many ways to approach SEAD curricula. One way to do so is to explore the affordances of self-organized, emergent learning, within the global interaction and collaboration that the internet and its increasingly intuitive and ubiquitous interfaces makes possible.

Emergent learning is self-organizing, distributed, networked and collaborative, open and adaptive, and although it is not predictable, it is still organized. In fact, without some constraints, emergence unravels over the edge of chaos into disorder (5).

Emergent learning provides a unique set of creative opportunities - and limitations -within which SEAD curricula can be designed and developed. It does not offer predictability, or compliance with prescribed outcomes; these should be explored within other frameworks. It needs to be integrated into a learning landscape that includes emergent and prescribed learning, in which the emergent learning needs to be designed by 'negative constraint', not positive outcomes, turning conventional curriculum design (temporarily) on its head.

Action 1: Develop, and Communicate the Value of, SEAD Curricula

Barrier: SEAD curricula include disciplines which are creative and innovative, as well as insights and which are applied across cultures and disciplines. However, in the UK in particular, the Higher Education sector has demanded more predictability and more micro-management. So there are few opportunities to develop and use innovative SEAD curricula.

Target: First and foremost: practitioners, designers and participants in SEAD learning. They have the most at stake. Secondarily, administrators and policy makers.

Solution: Tools for Designing and Describing SEAD Curricula

Suggested Actions: Identify and develop frameworks and graphic formats and tools for designing, describing and communicating the value of SEAD curricula. Many of these will include emergent learning. The 'Footprints of Emergence' is one framework and 'toolset' which has specifically been developed with emergent learning in mind. It should be tested on a wider scale, and developed further. Others need to be explored too.

Action 2: Theoretical Frameworks for SEAD Curricula

Barrier: SEAD curricula, by definition, do not operate within disciplinary boundaries, which means they often lack the academic recognition and intellectual legitimacy of individual disciplines, built up over the years.

Target: Researchers, teachers, policy makers.

Solution: Identify, develop and disseminate relevant theoretical frameworks

Suggested Actions: There are many types of SEAD curricula, which possibly draw on as many types of theoretical frameworks for their design and practice.

These need to developed, made more explicit, and applied and disseminated to underpin the recognition and legitimacy of SEAD curricula, as well as to inform better design, practice and evaluation.

The theory of emergence, is one such framework. It has arisen out of the specific need to understand current developments in in emergent learning, and to inform design for emergence in practice. It is based on an established body of research in Complex Adaptive Systems Theory (CAST), which already informs practice and research on Communities of Practice, connectivism, and networked learning. (5, 6).

The theory of affordances is related framework. It has arisen out of the work on perception, action and interaction, in ecological psychology, based on the earlier work of J.J. Gibson (7). It deals with the way in which people create new ways of thinking and doing things, in interaction with their environment as a whole, which often includes work across disciplines.

The theory of synaesthesia and embodied learning. The work of Ramachandran on synaesthesia and cross-modality is key to understanding embodied learning, and the use of metaphor and multimedia in open and cross-disciplinary learning (8).

Action 3: Develop a Knowledge Bank of Exemplars of Emergent Curricula and Courses

Barrier: Educational policy makers and administrators have little tolerance for cross-disciplinary study, whereas an a small but increasing number of academics and SEAD practitioners are enthusiastically working with their colleagues and professional practitioners in emergent learning. Particularly because emergent learning is not aimed at producing predictability and 'best practice', but rather unpredictable, 'interesting and inspiring practice', and emergent curriculum design is based on defining negative constraints rather than positive outcomes, there is a lack of understanding, or appreciation for the value of, emergent learning. There often isn't a common framework for dialogue, let alone a working relationship.

Target: Faculty and collaborating practitioners, administrators and managers, policy makers.

Solution: A Knowledge Bank and Community of Practice, based on Exemplars of Emergent Learning Practice

Suggested Actions: Create a knowledge bank of exemplars of interesting and inspiring emergent learning and curricula, using a practitioner- and designer-generated, tagsonomy of for courses and events that contribute to the development and design of emergent SEAD curricula. Appendix 2 lists and describes several such exemplars. Further research is needed to systematically identify, describe, and tag more emergent practice. The current explosion of interest, and creation of new courses in MOOC of one kind or another would be a good place to start.

Conclusion

SEAD curricula are both a challenge and an opportunity. There are substantial opportunities for SEAD initiatives to build on recent research and practice in emergent learning, in terms of a theoretical framework, a design and research tool (Footprints of Emergence), and in terms of several exemplars of interesting and potentially inspiring practice.

Based on this, a number of actions are suggested, including using and further developing the theoretical framework and the descriptive and design tools, and creating a knowledge base within a Community of Practice on emergent curricula and learning in the SEAD domain.

References

1. Williams, R. (2012) Affordances and the new political ecology. In: Terrorism and affordance. New directions in terrorism studies . Continuum, London, pp. 93-120. ISBN 9781441133816
2. Williams, R. Mackness, J. and Gumtau, S. (2012) Footprints of emergence. International Review of Research in Open and Distance Learning, 13 (4). pp. 49-90. ISSN 1492-3831
3. Williams, R., Karousou, R., and Mackness, J. (2011) Emergent learning and learning ecologies in Web 2.0. International Review of Research in Open and Distance Learning, 12 (3). pp. 39-60. ISSN 1492-3831
4. Daniel, J. (2012) Making sense of MOOCs: Musings in a maze of myth, paradox and possibility Seoul: Korean National Open University
5. Cilliers, P. (2005). Complexity, deconstruction and relativism. Theory, Culture and Society, 22(5), 255-267.
6. Snowden, D.J., & Boone, M. (2007). A leader's framework for decision making. Harvard Business Review.
7. Gibson J. J. (1977) The Theory of Affordances, in R.E. Shaw and J. Bransford (Eds): Perceiving, Acting and Knowing. Hillsdale, New Jersey. Laurence Gilbaum Associates.
8. Ramachandran, V.S. (2003). The Emerging Mind: Purple Numbers and Sharp Cheese. Reith Lectures. Retrieved 2012-07-16
9. Radiography and fine art
10. Affordances for Learning (2009) HEA Project report. Retrieved from: http://learning-affordances.wikispaces.com/Project+Report
11. Mackness, J., Mak, Sui, Fai, J., & Williams, R. (2010). The ideals and reality of participating in a MOOC. In Networked Learning Conference (266-274). Retrieved from http://www.lancs.ac.uk/fss/organisations/netlc/past/nlc2010/abstracts/Mackness.html
12. Mak, Sui, Fai, J., Williams, R., & Mackness, J. (2010). Blogs and forums as communication and learning tools in a MOOC. In Networked Learning Conference (275-284). Retrieved from http://www.lancs.ac.uk/fss/organisations/netlc/past/nlc2010/abstracts/Mak.html
13. Gumtau, S., Newland, P., Creed, C. & Kunath, S. (2005). MEDIATE. A Responsive Environment Designed for Children with Autism. Accessible Design in the Digital World Conference.
14. Gumtau, S. (2011). Affordances of Touch in Multi-Sensory Embodied Interface Design. Unpublished PhD thesis, University of Portsmouth, UK.
15. Wellcome Collection unveils £17.5m expansion project, retrieved 14/11/12 http://www.bbc.co.uk/news/entertainment-arts-20055213).
16. Brains – the Mind as Matter, Wellcome Collection website, retrieved 14/11/12from http://www.wellcomecollection.org/whats-on/exhibitions/brains.aspx).
17. Williams, R. Mackness, J. and Gumtau, S. (2014) Synaesthesia and Embodied Learning. Under submission – forthcoming.

Appendices
1. Frameworks for Emergent SEAD Curriculum Design
2. Exemplars of Emergent Design and Practice

Appendix 1: Frameworks for Emergent SEAD Curriculum Design

1. Innovation across 'cultures'
In broad terms, learning and/or innovation may result from interactions between ideas and practice from different disciplines or cultures, which may resonate with (or challenge) each other, when brought together.

There is no hard and fast boundary between ideas and practice. Nevertheless, we can distinguish different ways in which such resonance takes place: within an exchange of ideas, or practice, or both.

Ideas - Ideas
For example, the idea of *self-organised adaptation and innovation*. There are aspects of self-organized adaptation and innovation in social, psychological, biological, and physical systems that may resonate between disciplines, within the overall notion of emergence, and/or evolution, across all these different perspectives and intellectual 'cultures'. This cross-pollination may result in learning and innovation.

Practice – Practice
For example, the way images are captured and created, in fine art in radiography. There are aspects of a particular practice which are common across different disciplines (like capturing images) which may resonate at the level of practice. This may involve resonance and inspiration from one technique and discipline to another (9).

New Affordances
This kind of resonance or borrowing might result in quite new ways of doing things; exploring and establishing *new affordances* in one practice, based on an example of a related practice in another.

Ideas – Practice – Ideas.
Within an individual or a team's work and learning, the interaction between ideas and practice is likely to be a regular feature, repeated iteratively within the process of adaptation, development and innovation. This may occur within a single discipline, but it may equally occur across disciplines.

The development of the theory of affordances for learning, for instance, featured centrally, over two and a half years, in the *Affordances for Learning* project team, which explored the theory of affordances using insights from evolution, biological ecology, media theory, learning theory, and evolutionary psychology. These insights were used on an iterative basis, together with expertise in interactive media design, in the development of practical tools to create open, emergent affordances for professional reflective practice in a new 'nested narratives' methodology. This

was written up in a methodology paper, a theoretical paper on affordances for learning, and a project report for the funders (10).

The theoretical paper in turn served as an input into a seminar on Affordances, Political Violence and Terrorism, and has subsequently been rewritten, and published as a chapter on *Affordances and the new political ecology*, in a book on Terrorism and Affordance (1). This chapter, in turn, has recently been used in a publication on Enterprise Resource Planning, in business information systems.

Appendix 2: Exemplars of Emergent Design and Practice

Emergent learning, because it is based on self-organized actors, is paradoxically unpredictable yet organized. There must be some organization, as without any constraint at all, emergence is likely to tip over the edge of chaos into total disorder. So how is it possible to design for emergence? The answer is surprisingly simple: by negative constraint, rather than positive outcomes.

When you design for emergence you turn the curriculum process on its head. As far as possible, you specify what is NOT going to happen, rather than what IS going to happen (which is the traditional way of designing a curriculum).

This is evident in several layers of the MEDIATE project, somewhat differently within the curating of The Brain exhibition, and in the Montessori classroom. Emergence is also present to a varying extent in CCK08 (11, 12), and the Entrepreneur courses and Teacher Training courses, all of which are described in the *Footprints of Emergence* Paper.

2.1 MEDIATE

The details of what happened with in the MEDIATE project itself can be found in the Footprints of Emergence paper (2). This section will deal with related events, and with emergent learning in the MEDIATE development team, which included people from across the SEAD spectrum: artists, designers, computer engineers and scientists, and psychologists. It was based on the initiative of a design team at the University of Portsmouth (including sound artists, architects and a psychologist), who had some experience in developing interactive systems utilizing artificial intelligence, specifically to train fire chiefs in a simulated emergency scenario.

In MEDIATE, they were interested to develop an interface that addressed all the senses in a responsive environment, and could grow intelligently in dialogue with the user. This cross-disciplinary team then sought out collaboration from Europe, which was a condition of the research funding institution (the European Union). This itself was a somewhat emergent outcome, as the project struggled to find support in both Arts and Science camps, both contesting ownership. The two international design teams were approached on the basis on their expertise and/or previous successful collaboration with the team at Portsmouth.

The sound design team at the Hogeschool vor de Kuensten in Utrecht, Holland, was responsible for designing the 'intelligence', in other words the pattern detection software adapted especially for recognizing repetitive behaviour in MEDIATE. This software was based on a previous project, the *Signature Analyser*, designed to detect idiosyncracies in human jazz saxophone players. The visual design team at the Universitat Pompeu Fabra in Barcelona was based on the partnership between Narcis and Roc Pares, two brothers who collaborate regularly as artist and programmer, to create innovative interface designs.

The brief of the project was initially based on a commonly agreed diagnosis of autism and its symptoms (informed by the psychology team), for example: sensory hyper- and hypo-sensitivies, lack of communication, repetitive behaviour, and avoidance of novelty. The vision of this interactive space was that this could be a safe place for a child with autism and low verbal skills to interact, explore, communicate and be creative – something that is normally seen as a deficit in people on the autistic spectrum. The brief developed as the project progressed, as a tacit understanding of the interactive space, and how it was going to be created.

A project on this scale and this complexity in research aims and technical accomplishment had never been done before. The space was effectively developed by an iterative series of developments – ideas and practices – which increasingly defined the 'open' outcomes of the project, and the MEDIATE space, by increasingly agreeing on the nature – and limitations – of the *negative constraints* that would define the open, unpredictable outcomes within the interactive space. Emergent design values centred, unusually, on openness and uncertainty, and sought to define minimal, but necessary, constrains – from the 'outside' as it were. It was an evolutionary approach in the sense that both the structure (of the event), and the agency (of the participants) are expected to adapt, change and co-evolve.

In the case of the MEDIATE space, it was not only interactive, but was programmed (literally) to respond adaptively and unpredictably (within constraints) – as a kind of proxy 'mind' to respond to the participants behavior, and establish a kind of dialogue (13, 14).

This also applied to the project team – because the teams were in different locations around Europe, face-to-face meetings were limited and costly. Although all members spoke English very well, there were often misunderstandings that could only be articulated and resolved in these meetings, so project development was a lot more efficient at those times.

However, it was important that there was a shared design rationale when members were working away in their local teams. Many discussions focused on the ethics and potential dangers of producing a responsive environment for vulnerable children, and in the end it seemed there was a very strong shared vision of what was not going to happen. In fact this vision was so strong that one member of the consortium could not continue with the collaboration, as they were arguing very strongly for the sort of things the rest of the team had decided they definitely did not want to aim for. So the learning of the team, seen as a collective individual, was also managed (tacitly) by iteratively clarifying the negative constraints within the emergent development of the project.

The participants who entered the interactive MEDIATE 'room' were not expected to behave in any particular way, or to carry out, or develop, particular kinds of responses. Crucially, it was

hoped that the space would be engaging and open enough for them to "take charge" of what they did – to develop agency, which they did – in develop their own, very different responses, which surprised nearly everyone concerned. If there was a positively defined outcome, it was this – the participants did develop agency, and a strong sense of *self-in-engagement with the world* around them – but, crucially, without having to comply with any specified 'content'. They were, predominantly, children on the Autistic Spectrum.

The emergence – the continued interaction, adaptation and co-evolution between the participants' agency and the structure of their immediate environment – continued after and outside of the participants' engagement with the MEDIATE space, particularly in the case of 'Mr. Purple', a child who had honed in on the colour purple in the interactive space. His family and carers, after discussion with him, painted his bedroom purple, and he slept through the night for the first time in many years.

The participants' learning was impressively emergent, as well as being positive in terms of their own development, but it was the development team's learning which is the real exemplar of learning across the SEAD spectrum – albeit in more of a 'project' than a conventional 'course'. There is of course plenty of room for the application of the MEDIATE team's experience to more conventional project-based, research-based and problem-based learning, all of which are well established in higher education.

2.2 The Brain

The Brain – Mind as Matter exhibition at the Wellcome Collection in London in 2012 is the most visited installation there to date (15). It received a total of 105,033 visitors during its run. Art historian Marius Kwint, a senior lecturer in Visual Culture at the University of Portsmouth guest curated this exhibition, which featured over 150 artefacts including real brains, artworks, manuscripts, artefacts, videos and photography – both commissioned and found.

According to the press release, the exhibition sought to "to explore what humans have done to brains in the name of medical intervention, scientific enquiry, cultural meaning and technological change… 'Brains' asks not what brains do to us, but what we have done to brains, focusing on the bodily presence of the organ rather than investigating the neuroscience of the mind." (16)

Working with the Head of Public Programmes at the Wellcome Collection, the brief, similar to MEDIATE, could be seen to be very much centred on what was to be avoided (negative constraint). In this case, both parties were very clear that they wanted to avoid visual clichés and ephemera, such as the ubiquitous brain scan images in contemporary visual culture. The viscerality and materiality of the brain, the brain as an embodied organ rather than emphasis on the workings of the brain was to be at the centre of interest (also utilizing to full extent the Wellcome Trust's human tissue licence and collection).

Kwint reports that his job as curator was very much to weave these elements into a narrative which could have potential for emotional content / communication / impact.
This is not the first project on this subject matter for Kwint, as he was also involved in an exhibition around the dendritic (branching) form in nature and culture, called

Einfach Komplex (Simply Complex) at the Design Museum in Zurich in 2005.

Based on this, he developed a sense for the medium of exhibition as a form of embodied communication with very particular affordances. This medium allows the curation of content in a way that is experienced and digested in a very different way than web page content would be, for example. Not only is it a designed space involving full body interaction, it also presents information in a certain sequence or patterns. However, Kwint says they were very concerned to avoiding a didactic exhibition in a scientific sense, and not to teach brain functions in a classical way, but rather to offer an open narrative which could be explored by visitors on their own terms – in a way, as self-organising agents.
This can only be described as a resounding success, as the figures and other evidence show – with the appeal ranging from school children to veteran neuroscience experts, re-connecting with their passion and interest in what motivated them to go into the field in the first place.

The engagement with the 'mind as matter' merged different kinds of embodied learning – across science, biology, art, and intellectual and emotional responses. In terms of SEAD curricula, it is an inspiring example of how the choice of a particular, and in many ways unusual choice of the mode of interaction – in this case primarily 'embodied' (in a multitude of different ways) rather than intellectual or conventionally scientific - can be used to engage an audience whose identities were drawn from a range of very different roles, within a vast range of social, scientific and artistic disciplines, and 'cultures'.

2.3 The Montessori Classroom

The Montessori classroom arose out of practical, scientific innovation. Montessori, at heart a mathematician, and the first woman doctor to qualify in Italy, initially took on the task of teaching 'mentally disabled' children. The approach that she adopted in her design and development of the Montessori 'materials' (embodied proxies of an open curriculum), as well as in the learning materials themselves was, implicitly, a SEAD-type curriculum. Both her research and development, and the children's engagement with the materials includes was based on a scientifically rigorous, design informed, aesthetically sensitive, emergent learning framework, integrating insight and content from mathematics, biology, and medicine, psychology, linguistics/semiotics, the humanities, aesthetics and what we have recently come to recognize as the cross-modality of synaesthesia and embodied learning.

For all that, she consistently maintained that "there is no such thing as the Montessori method", just "follow the child". However, to follow rather than to lead turns the whole notion of education (from the Latin, educare, to lead forth), and traditional curriculum design on its head.

The core of her method was to scientifically and rigorously observe each child, each day, against the whole range of knowledge about child development at the time (which required her to be something of a poly-math), and then to design, engineer and produce aesthetically pleasing materials, appropriate for a range of 'sensitive periods' for child development, for the children to work with, based on their own internal motivation – effectively their own self-organised and self-managed learning, albeit in a deeply intuitive rather than an intellectually scaffolded manner.

This was evidence- and research- based observation, design, construction, and practice, within an intuitive-aesthetics. It was based on her observation that children (including her initial, 'mentally defective', charges) really want to learn – they have almost unlimited internal motivation for learning, if you are capable of designing and providing them with the materials they need to work with.

This resonates with the MEDIATE exemplar, as in both cases the learning in the design team, or collaborative group (Montessori worked with Piaget, amongst others) as well the learning of the participants in the actual learning environment, happened across 'cultures' including most if not all of the SEAD disciplines.

In all three of these exemplars learning is grounded, substantially, in embodied learning, often with little or no instruction, and certainly with remarkably little linguistic or intellectual scaffolding. This is not to say that emergent learning is in any way confined to embodied learning, but it does point to interesting alternative affordances for learning, and complementary modes of interaction. Embodied learning, in turn can be seen as grounded in cross-modality and what can be called 'synaesthetic scaffolding' (17).

Can Art Advance Science? A Hypothetical SEAD Experiment

http://wp.me/P2oVig-9L

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Key Words: Transtechnology, Embodied Learning, Self-Determination Theory, Sonification, Visualization. Art-Science

Abstract

Can SEAD collaborations contribute to the production of scientific knowledge? In this paper, we describe how such ends could hypothetically be achieved through experiencing the Krebs cycle as a multi-sensory spectacle, henceforth referred to as the Dance of Life. We propose the Dance of Life as a transdisciplinary experiment in the form of a machine-mediated embodied learning experience which will generate a high order integration of basic scientific information through the rhythmic visual and sonic intensification of memory. The critical test of this proposed experiment's value is whether this learning experience might advance biochemistry? Thus beyond the Dance of Life's intended function as an innovative pedagogical device, the experience must in the end prove useful in furthering scientific knowledge. If not, it will have failed to have achieved its transdisciplinary purpose and to have met the challenge of whether the arts can demonstrably contribute to the advancement of science.

Introduction

The purpose of this SEAD collaboration proposal is twofold: to support science education and to potentially advance research in biochemistry (and similar fields). Can we make the integrated complexity of the most iconic process in biochemistry, the Krebs or Tricarboxylic Acid (TCA) Cycle, more accessible to the general public and support science education in the process? This cycle is the primary metabolic pathway for the production of biological energy in cellular respiration (Eswaron 2005, Nelson 2008, Prebble 2002). [1] While the specifics of the process (the names and structures of the molecules and the molecular and atomic reactions at each step) require a basic knowledge of upper level high school chemistry and biology, this project intends to invert the learning process. Through visual, sonic, and embodied means, we propose the Dance of Life to foster an aesthetic and intellectual appreciation of the dynamics of the whole Krebs Cycle and its constituent parts through experiential means regardless of the learner's level of scientific literacy.

We hypothesize that the experience may allow future scientists to better imagine molecular structures in complex cyclical and directional processes, resulting in insights into the study of chemical systems that might not have come about otherwise. The success or failure of the proposed experiment would be based on testing one specific outcome: Could high school and college science students more easily understand the Krebs cycle through the internalization of the Dance of Life's sonic and visual cues initiated through physical motion? If the Dance of Life did achieve this goal, the machine would serve as a cognitive extension device, being an embodied learning tool. If not, the experiment would have failed the test of transdisciplinarity and amounted merely to a creative interdisciplinary exercise.

Transdisciplinarity is fundamentally different from interdisciplinarity (Zilberg 2011). Transdisciplinary research requires that each of the disciplines in the collaboration contribute in and of themselves and not merely to a synthesis. As a trans-disciplinary project, the Dance of Life must advance science education and ultimately science or it is not, by definition, a SEAD collaboration. Without advancing science, the experiment would simply recapitulate the primary problem in the decade long SCIART project in the UK (Glinkowski and Bamford 2009, Ione 2010). Thus in the context of taking up the challenge provided by the NSF Beyond Productivity report (Mitchell, Inouye and Blumenthal, 2003) and the importance of the arts to education (Marjee 1995, Tyler, Levitin and Likova 2008), we emphasize that such science-art collaborations are not contributing significantly to science. They have merely resulted in art projects inspired by science. As these NSF SEAD White Papers are meant to identify constraints, roadblocks, and opportunities, in this emerging SEAD collaboration we explain our design to overcome obstacles and meet the challenge of how the arts can hypothetically be productive for science as opposed to the sciences for the arts, as for instance in the case of evolutionary theory for art history (see Bork 2008) in contrast to literary criticism for science (Clarke and Rossini 2011, Roof 2007, Zilberg 2009, 2012). So can scientists dance? (Bohannon 2008)

Musical Biochemistry, Visualization and Memory

Scientific visualization, visual music, musical biochemistry and digital visualizations of chemical processes are not new (Johnson 2012, Kostis and Cohen 2012, Long 2001, Miller 1983, Simmons 2002, Syelingwerf 2005). [2] Over time, especially throughout the last decade, such approaches are becoming increasingly effective and refined, even popular (Bohannon 2008, Cai et al 2006, Dunn and Clack 1999, Garcia-Ruiz and Guitterrez-Pullido 2006, Hiroshi and Yoshima 2006, Jensen and Rasay 2001, Miller 1983, Mody 2005, Shi, Cai and Chan 2007 and Takahashi and Miller 2007). These musical and animated approaches satisfy a need for finding more effective ways to communicate complex scientific information than traditionally achieved through lectures, text books and rote memorization. In the UK, the field of molecular music was pioneered in the 1990's by the NESTA award winning biochemist Linda Long and the first interactive exhibit of protein music was installed at Explore at-Bristol in 2002 (Simmons 2002) and ran successfully for a 10 year period. And as Long contributes here, musical biochemistry allows the student to overcome the overwhelming sense of alienation that scientific jargon tends to produce for so many of them: "Music is a universal language which speaks both to our conscious and unconscious and is hence a perfect medium to communicate complex scientific principles in an intuitive and accessible way."

In the US, this pedagogical movement towards more visual and musical approaches to biochemistry was also well illustrated over a decade ago with the USDE/NSF funded North Dakota State University Virtual Cell Animation Project through sound, video and text, 3D downloads, and visual navigation tools designed to accompany the third edition of Lehninger's Principles of Biochemistry (Nelson and Cox 2000, also see Nelson 2008). In this context, a 21st century generation of image-based technologically-assisted learning has emerged. At the same time, a plethora of attempts by both professional and amateur attempts at putting the Krebs cycle to music has found its way onto Youtube, the current leaders in these US based experiments being in classes at the Khan Academy and Oregon State University. This diverse activity highlights the potential for this particular SEAD collaboration to make meaningful contributions to a developing field and help science students conceptualize simple and complex molecules, enzymes, protons, and electrons in motion during biochemical processes.

Discussed in more detail in the next section, we imagine the musical translation of glycolysis as the opening phrase to repeated as the chorus at every completion of a cycle. The main body of the repeating composition would represent each step of the Krebs cycle itself, including the generation of ATP, NADH and FADH2 and all other inputs and outputs. The Electron Transport System (ETS) would provide for an elaboration in the music representing hydrogen ion transfer.[3] With each cycle of single molecules of glucose breaking down, the composition would alter such that it signified in volume and modulation the exact amounts of ATP (energy) consumed and generated. At this point in musical biochemistry, while musicians and scientists have already used scientific data to create musical compositions, Dr. Long's technique of translating 3D protein structure to music remains unique in its ability to accurately depict the twists and turns of a protein's secondary structure by way of corresponding musical patterns. It is hence well placed to act as an auditory tool to actively engage students with the protein structures of all the enzymes involved in catalyzing the Krebs cycle.

Beyond the musical experience, could this experiment significantly advance imaginative scientific capacity and stimulate the subconscious mind. If so would this result in scientific insights that might not have occurred otherwise? Recall that our current understanding of the Periodic Table, the double helix, and the benzene ring all grew from the subconscious dreams of scientists (Strathern 2000). As regards memory and learning, as Long notes and as is expanded upon in the Appendix, the human mind is biologically wired in a way which predisposes the success of this hypothetical experiment. "Our brains have evolved to recognize auditory patterns and so intuitively we are able to discern and remember repeating musical themes. Protein molecules themselves are made up of repeating structural units (sheets, turns, helices). and so their accurate translation into musical notes create uniquely recognizable and memorable musical note patterns." Hence beyond the musical representation of the transformation of the glucose molecule in the Krebs cycle, if Long's molecular music was used to "visualize" 3D molecular structure of the Krebs cycle enzymes, the goal to aid memory by simplifying connection to complex data while making the "invisible visible" could be achieved for this part of the exhibit in particular.

The Machine and the Dance

The space of the gallery itself, designed as a single cell, will mainly be taken up by an open-ended transparent 3D mitochondria within which the cyclical dance occurs. Each of the eight steps in the Krebs cycle, including two for glycolysis (simplified from nine), will be depicted on plexi-glass pressure plates covering the museum floor. The ETS will be depicted around the walls as illuminated energy cascades. A pillar of light depicting ATP production would emerge from the center of the mitochondria and reach up to the gallery's roof. As one jumps up and down on a plate or from one plate in the cycle to another, the accompanying molecule's name and 2D molecular structure will be lit up in the plexi-glass plate.

Each step is sonically projected and musically indexed such that the musical score reads as an analog to the chemical process. As the participating learner lands on a plate, the name of the molecule can be voiced, musically expressed, or even silenced to focus on purely visual learning, depending on the preference of the learner participating. Each molecule will have an associated and variable chord structure, and would ideally also be made visible in 3D and in rotational motion. The transformation processes will be musically experienced and visualized with the learner generating and actively engaging in the experience through physical action. As the individual jumps or dances from plate to plate, moving around and around the cycle, they will actively acquire scientific knowledge through an embodied multi-sensory learning experience. Each dimension (visual, sonic, and physical) poses particular artistic and technical challenges.

All the necessary technology is available and has been used in similar ways, such as interactive dance machines in gaming arcades and the Pavagen foot fall energy harvesting system showcased at the 2012 Olympic Games (www.pavegen.com). In addition, all of the enzymes catalyzing the Krebs cycle reactions can currently be translated to music using Dr. Linda Long's Molecular Music technique. For instance, Long also notes for this application that it would be feasible to place touchscreen molecular models of the enzymes catalyzing the reactions between the relevant plates. By touching these screens while moving from one plate to the other, additional music could be generated that accurately reflects the shape of the specific enzyme required for that chemical reaction. Additional tracks could then be added by the user (or others as they joined the exhibit) to contextualize the "protein melody" and create a much more orchestral form of music than that produced by the simple eight step cycle itself and the nine steps for the glycolysis chorus. This additional musical richness and the expanded participation it encourages would make the experience even more emotionally engaging, so fulfilling the criteria of relatedness in self-determination theory as considered further below.

The machine will be programmable for different musical style options depending on the preferences of the participant, with the goal of engaging diverse audiences. Upon entering the machine, participating learners will be prompted to choose their desired musical style so that they can emotionally connect to the experience in their own way. Regardless of style, the music will become progressively livelier as the participating learner picks up speed. The rhythm will intensify and the volume will increase in relation to the theoretical energy produced by the number of cycles danced. The experience will be both artistically and musically powerful. The music and the machine would naturally climax at an inbuilt maximum synergistic potential when the machine is mastered and a unique rhythm established. As a site-specific performance artwork

as well as a pedagogical experiment for science education, the Dance of Life will be tested in different international contexts. Including pre- and post-testing of the potential learning outcomes it will ideally be tested in art museums and science centers linked into local school and university science curriculums.

Viewers watching from outside or from above would indirectly gain the same knowledge through the visual and sonic dimensions. When no participants are using the learning apparatus, it will operate in auto-pilot, switching randomly from style to style and at varying speeds. The machine will be programmed to generate a continual aesthetic experience for museum visitors who prefer not to directly physically engage the experiment. The exact molecular and mathematical factors will be accurate at every step as well as cumulative and ideally synergistic. The complete experience will be aesthetically compelling. The machine will provide a spectacle, a visual and sonic experience of the overall reaction, the production of energy in the phosphorylation of ADP to produce ATP, and the mechanism of the ETS cascades. These offer powerful opportunities for the dynamic representation of atoms, molecules, and energy in motion, with color and music far in excess of what has been attempted so far for the Krebs cycle or in other embodied learning experiments in art education (Kuper, Zilberg and Bales 2000).

Towards Collaboration: Self Determination Theory

One intended consequence of this SEAD proposal was to draw in collaborators towards eventually creating and testing the proposed learning machine as a cognitive extension device. Depending on the collaborators, very different SEAD components will need to be addressed. At this point, the most progress has been made conceptually at the pedagogical as well as musical and choreographic level and the least in terms of engineering and design. One example of the potential value of such collaboration was supplied by Kathryn Trenshaw, a graduate research assistant in the Department of Chemical and Biomolecular Engineering at the University of Illinois at Urbana-Champaign. Her contribution was to introduce the relevance of self-determination theory (SDT) and how it can be used to enhance the model and expand its potential applications as a learning device in science and engineering contexts. Two other scientists have contributed. Dr. Linda Long's contributions are integrated throughout this paper including in the section on molecular music appendix where suggestions by Dr. Helen-Nicole Kostis.of NASA Science Visualization Studio are also included, Dr. Kostis making particular note of extending the following discussion by Trenshaw. Dr. Kitto due to illness was unable to contribute his long standing thinking on synergistic properties of reactions in the Krebs cycle. Nevertheless, as this is merely a hypothetical paper towards a pedagogical experiment, it is hoped that the availability of this SEAD NSF White Paper will stimulate scientists to follow suit in due course.

As Trenshaw brings it to this collaboration, SDT identifies three important aspects of motivation: autonomy, competence, and relatedness (Ryan & Deci, 2000). Autonomy refers to a person's ability to make their own choices, competence refers to a person's feeling that they have mastered the skills necessary to succeed, and relatedness refers to a person's sense of community. The theory has a particular applicability in terms of learning in education and edutainment, specifically as it has proven pedagogical effectiveness in virtual environments and video games (Przybylski et al, 2012). The focus of this proposal is on embodied learning in which the physical

senses are used as cognitive extension devices for learning through embodied means. The notion of the machine has evolved from that larger context, originally formulated as a board game called Biozopoly in the earlier days of Edutainment, then as a computer game, and finally here as a proposed engineered embodied experience.

SDT can be drawn upon to strategically design a learning apparatus that people of all backgrounds, abilities, and educational experiences will be motivated to use. For instance, autonomy can be supported by providing several options for how to interact with the learning apparatus. Different paths could be made available to move around the apparatus that lead to the same learning outcome (achieving the highest possible competence in understanding the Krebs cycle). There should be a sense of choice and ownership of the learning such that participating learners could dance it backward or forward two steps at a time while learning the cycle at their own speed and in their own way. Developing competence will therefore be implicit in the design.

And as Trenshaw emphasizes, participants will be made aware that they need not be a scientist to interact with the machine. They only need to use their body as an instrument of learning and everything will naturally follow. Consciously or unconsciously, the internalization of knowledge will take place as a natural consequence of the motion and the combined physical, visual, and sonic experience. Relatedness presents a motivational learning opportunity if adding participants improves the experience. For example, increasing the number of screens that display information or playing new parts of a musical composition in the background as new participants joined the experience.

Lastly, with such adaptability, flexibility, and extendibility in mind, Trenshaw notes that it would be possible to design an even more complex apparatus that could be easily changed from one concept to another. For instance, one could program the experience for something as simple as learning multiplication and division, the Periodic Table, the cycle of water in the environment or the Calvin cycle and other circular chemical reactions including cyclic and non-cyclic chemiosmosis. Switching a DVD or swapping out a hard drive could provide a new program which would reconfigure the pressure plates and the associated configurations of words, images, and music. Collaboration thus offers the power of vastly expanded potentials and contexts for the experimental machine (Brickwood 2007, Ione 2002, Zilberg 2008). [4]

Conclusion

The transdisciplinary opportunity presented by the Dance of Life is designed to induce a complex, physically heightened, subjective, and aesthetic perception of an iconic cycle in biochemistry. Ultimately it could contribute to science by stimulating an increased cognitive sophistication amongst future scientists in terms of how they conceptualize the bioenergetics of molecular processes (Prebble and Weber 2008). With an internalized sense of the dynamic dialectical whole, complexity, and homeostasis (Levins and Lewontin 1985), the horizon for science education and research practice can potentially be expanded in new dimensions. In that future-oriented context (Woese 2004), this hypothetical experiment is designed to entice future students into science, assuming it could be engineered as a highly compelling creative experience. The experiment's pedagogical purpose is to enhance in advance the learner's capacity to conceptualize the structural and energetic dynamics of the molecular transformations

and processes involved in this and consequently other cyclical or non-cyclical directional chemical processes.

In "Cycles", a pod-cast Edge presentation (Dennett n.d), Daniel Dennett, a philosopher at the Center for Cognitive Studies at Tufts, notes that "the key process in evolution is cyclical repetition" and that in employing this process, the Krebs cycle provides an essential resource for the cell. As he puts it, the system is a "flexible and rapidly tunable device" which serves as a molecular transistor, "a micro-miniaturized engine", an "eight-stroke chemical reaction that turns fuel – into energy . . . ." With that engineering metaphor in mind, coupled with the musical dimension, consider Shi, Cai, and Chan's goal with their electronic music for biomolecules (2007). Their hope was to simultaneously unveil the mysteries of nature and motivate students to learn biology while paying special attention to using rhythms and tunes that are meaningful to teenagers and experimenting with non-Western musical instruments and forms (also see Cyranoski 2005).

To conclude then, in this experiment in embodied learning, the participant will experience the Krebs cycle as a multi-sensory spectacle and hence intensify the holistic knowledge of the processes involved. The machine and the experience must contribute to scientific knowledge. It has to be able to do more than simply foster an expanded dialectical sense of biochemistry and molecular biology. It will have to generate productive scientific insight that can be proven through future experimentation. The single criterion for assessing its ultimate success or failure is therefore clear. Can art contribute to science? That remains the penultimate SEAD challenge and opportunity.

Suggested Actions

Suggested Action #1: SEAD Priorities

Barrier: Relevance to science is a major SEAD challenge. Few if any demonstrated cases exist which prove that Art-Science projects, extended now as SEAD projects, have or can contribute to the advancement of science.

Target: SEAD professionals, government funding agencies, university and science museum administrators, creative industry professionals

Solution: Prove the value to science of SEAD and XSEAD initiatives

Suggested Action: A nationally funded SEAD collaboration that advances science. In order to convince the scientific community of the potential value of the arts and the humanities to the sciences, proof of the supposition is required. This common argument for the importance of inter-disciplinary education has to be demonstrable. If so future funding and university based programs are far more likely to eventuate as valid institutional and national research priorities.

Suggested Action #2: SEAD Grants

Barrier: Securing funding for SEAD collaborations designed to test whether art can contribute to science can be difficult. Without funding, experimental SEAD projects cannot attract the necessary collaborators who have the skills and the resources available. Only with sufficient funding can the potential usefulness of engineering, the visual arts and design, the humanities in general, and dance and music in a transdisciplinary project be investigated.

Target: NSF, NEA, NEH, and NASA grant managers

Solution: SEAD grants

Suggested Action: Securing a large scale SEAD, XSEAD. STEM, or STEAM grant for open competition based awards would allow individual SEAD projects that have the potential to investigate the potential value of art to science. If the fact is established that there is no potential for the arts to contribute to science at the theoretical and experimental level, then the traditional argument must be made clearer that the real value of interdisciplinary and multidisciplinary education is of a more general educational purpose.

Notes

1. For information on and diagrams of the Krebs cycle see https://www.facebook.com/pages/Krebs-Cycle/47987249244). For highly accessible brief explanations and effective illustrations, see Aryulina et. al. Biology for Senior High School Grade XII (2012:44-47).

2. See The Molecular Music Website at www.molecularmusic.com for music samples and further information on how the music sequences are generated. For additional information about Molecular Music, see Appendix 1.

3. For simple information on and diagrams of the Electron Transport System, Chemiosmosis and Oxidative Phosphorylation see Molecular and Cell Biology for Dummies (Kratz 2009:171-175). Also see ATP Synthase Gradient: The Movie at www.vcell.ndsu.nodak.edu/animations/atpgradients/movie-flash.htm. For bio-visualization (bio-viz) and science-vizualization (Sci-viz), see the Osmos game at www.hemispheregames.com/osmos/ and Atlas in Silico at www.atlasinsilico.net/collaboration.html

4. The "Listen to Your Body" exhibit is a further example of how scientists, artists, engineers and software developers in the business sector collaborated successfully. "Listen to Your Body", the molecular music touchscreen exhibit at Explore at-Bristol Science Centre. This successful science exhibit ran between 2001 and 2010 and invited children of all ages to explore the protein hormones in their bodies by way of an

interactive touchscreen exhibit. Children of all ages accessed accurate 3D models of proteins and then heard how these models sounded when translated to music. They were then able to personalize their experience by adding and taking away backing tracks so that they could contextualize the "protein melody" into a piece of music that they emotionally related to. In addition, there was textual information about the role of the proteins that they were listening to, so providing a popular trans-disciplinary learning tool. Although not formerly assessed, the exhibit possessed many of the elements important for self-determination theory as detailed here by Kathryn Trenshaw.

Bibliography

Aryulina, D., C. Muslim and S. Manaf. Biology for Senior High School Grade XII. Jakarta:esis.

Bohannan, John. "Can Scientists Dance?" Science 318 (2008): 905.

Bork, R. O. "Art, science and evolution". In Making Art History: A Changing Discipline and its Institutions, ed. E. C. Mansfield, New York: Routledge, 2007, pp. 187-201.

Brickwood, Cathy et. al. Uncommon Ground: Creative Encounters across Sectors and Disciplines, Amsterdam, BIS Publishers, 2007.

Cai, Y. Y. et al. "Proteins, Immersive Games and Music." Leonardo 39(2):135-137, 2006.

Clarke, B. and M. Rossini. The Routledge Companion to Literature and Sicence. New York: Routledge, 2011.

Cyranoski, D. "Japan plays trump card to get kids into science." Nature 435:726, 2005.

Dennett, D. "Cycles." Edge. www.edge.org/print/res-detail.php?rid=927

Dewey, J. Art as Experience. New York: Perigree Books,1934/1980.

Dunn, J. and M. A. Clack. "Live music: the sonification of proteins." Leonardo 32:25-32, 1999.

Eswaron, S. V. "A new look at the citric acid cycle." INSA 43(4):237-253, 2005. www.new.dli.ernet.in/rawdataupload/upload/insa/INSA-2/2005ad3_237.pdf

Garcia-Ruiz, M. A., J. S. Guiterrez-Pulido. "An overview of auditory display to assist comprehension of molecular information." Leonardo 18(4):853-868, 2006.

Garrett, R. H. and C. M. Grisham. New Developments in Biochemistry. Belmont, CA: Thompson Learning, 2005.

Glinkowski, P. and A. Bamford. Insight and Exchange: An Evaluation of the Wellcome Trust's Sciart Program. London: Wellcome Trust, 2009.

Hess, B. "Oscillating reactions." Trends Biochem. Sci. 2:193-195, 1977.

Hiroshi, T. and T. Yoshimasa. "Molecular music: score generation taking account of structural similarity." Proceedings of the Annual Conference on JSAI, 20:363-365, 2006.

Ione, A. "ArtSci 2002: New Dimensions in Collaboration." Conference Review, Leonardo Digital Reviews, January 2003.

Jensen, E. and R. Rasay. "Musical representations of the Fibonacci string and proteins using Mathematica." Mathematica 8:55, 2001.

Johnson, Ken. 2012. Exhibition review Center for Visual Music's HD 3-screen Oskar Fischinger installation at The Whitney Museum. "Signs & Symbols" and "Oskar Fischinger: Space Light Art — A Film Environment" The New York Times, July 27. http://www.nytimes.com/2012/07/27/arts/design/signs-symbols-and-oskar-fischinger-at-whitney-museum.html

Kostis, H. N. and D. Cohen. "Science Visualization: When Art Meets Science and Technology." Ask Magazine: The NASA Source for Project Management and Engineering Excellence. Issue 47, 2012.
    http://www.nasa.gov/offices/oce/appel/ask/issues/47/47s_art_sci_tech.html

Kratz, R. F. Molecular and Cell Biology for Dummies. Indianapolis: Wiley, 2009.

Levins R. and R. Lewontin. The Dialectical Biologist. Cambridge: Harvard University Press, 1985.

Krebs, H.A. "The history of the tricarboxylic acid cycle." Perspect. Biol. Med. 14:154-170, 1970.

Long, Linda. Tuneful Proteins, New Scientist, September (2001) p.53.

Marjee, E. Eloquent evidence: Arts at the Core of Learning. Washington, D.C.: President's Committee on the Arts and Humanities, 1995.

Miller, J. N. Review. "The Biochemists Songbook by Harold Baum." J. Pharm. Biomed. Annal 1:379, 1983.

Mitchell, W. J., A. S. Inouye, and M. S. Blumenthal, eds. Beyond Productivity: Information Technology, Innovation, and Creativity. National Academies Press, Washington DC, 2003.

Mody, C. M. "The Sounds of Science: Listening to Laboratory Practice." Science, Technology, and Human Values 30(2):175-198, 2005.

Nelson, D. L. Lehninger Principles of Biochemistry. New York: W. H. Freeman, 2008.

Nelson, D. L. and M. M. Cox. Lehninger Principles of Biochemistry, 3rd edition. New York: Worth Publishers, 2000.

Prebble, J. "Peter Mitchell and the Ox Phos wars." Trends in Biochemical Sciences 27 (2002): 209-212.

Prebble, J and B. Weber. "Peter Mitchell: Changing the Face of Bioenergetics." In Harman, O. and M. R. Dietrich (eds.), Rebels, Mavericks, and Heretics in Biology, New Haven: Yale University Press, pp. 231-247, 2008.

Kuper, K., Zilberg, J. and Bales, S. "The Africa Project". Art Education. Special Issue: How History Can Come Together as Art 3(2):18-24, 2000.

Przybylski, A. K., Weinstein, N., Murayama, K., Lynch, M. F., Ryan, R. M. (2012). The ideal self at play: The appeal of video games that let you be all you can be. Psychological Science, 23, 69–76.

Roof, J. The Poetics of DNA. Minneapolis: University of Minnesota Press, 2007.

Ryan, M. R. and E. L. Deci. "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being." American Psychologist 55:66-78, 2000.

Safire, W. and J. Kagan. Neuroeducation: Learning, Arts, and the Brain: Findings and Challenges for Education and Research for the 2009 John Hopkins Seminar. In Dimensions, Special Issue Where Art and Science Meets, March/April 2012.

Shi, X. J., Y. Y. Cai and C. W. Chan. "Electronic music for biomolecules using short music phrases." Leonardo 40(2):137-141, 2007.

Simmons, Ian. Review. "'Music of the Body' by Linda Long". NTHPOSITION.
    www.nthposition.com/musicofthebody.php

Stellingwerf, M. Innovation and Visualization: Trajectories, Strategies, and Myths. Delft: Delft University Press, 2005.

Strathern, P. Mendleyev's Dream: The Quest for the Elements. New York: St Martin's Press, 2000.

Takahashi, R. and J. H. Miller. "Conversion of amino acid sequence in proteins to classical music: search for auditory patterns." Genome Biology 8:405.4, May 2007.

Tyler, C. W., D. J. Levitin and L. Likova. Report: Working on Art, Creativity and Learning (Executive Summary). Washington, D.C.: National Science Foundation, 2008.

Woese, C. "A New Biology for a New Century," Microbiology and Molecular Biology Reviews 68 (2004): 173-186.

Woese, C. "The Universal Ancestor," Proceedings of the National Academy of Sciences USA 95 (1998): 6854-6859.

Zilberg, J. Review of The Routledge Companion to Literature and Science (London: Routledge, 2011), Leonardo on-line reviews, November 1, 2012, leonardo.info/reviews/.../clark-zilberg.php

Zilberg, J. "Beyond the Estuary Metaphor". Leonardo Reviews Quarterly 1.04. Eds. Roger Malina, Michael Punt and Claudy Op den Kamp, pp. 1-12. Plymouth: ISAST, 2011. http://www.leonardo.info/reviews/LRQ/LRQ%201.04.pdf www.leonardo.info/reviews/jan2011/goodstein_zilberg.php

Zilberg, J. Review of Judith Butler. The Poetics of DNA (Minneapolis: Minnesota Press, 2007) Leonardo 43(2):189-90, 2009. in Leonardo on-line reviews, September 1, 2009. www.leonardo.info/.../zilberg_poetics.html

Zilberg, J. Review of Cathy Brickwood et. al, Uncommon Ground: Creative Encounters across Sectors and Disciplines (Amsterdam, BIS Publishers, 2007), in Leonardo on-line reviews, February 2008. http://www.leonardo.info/reviews/feb2008/un_zilberg.html

Appendix: Molecular Music, Discussion, Suggestions

Molecular Music

Molecular Music TM involves the translation of the 3-dimensional positions of a protein's amino acids into note sequences. X-ray crystallography data (describing the 3-dimensional positions of the amino acids in a protein molecule) is filtered and then mapped onto musical parameters such as pitch and amplitude. Data may be filtered to emphasize either small scale changes or large scale changes, so generating note sequences that describe protein structure on many different levels. In this way, characteristic patterns in protein structure such as helixes (heard as arpeggios) and beta-sheets (heard as a succession of similar notes) emerge as recognizable musical note patterns from the 3-dimensional structural data. The musically pleasing quality of such generated note sequences is incidental, although not surprising given that it is the repetitive patterns in music that we find most pleasing and memorable. There is no subjective "musical labeling" of amino acids in order to produce musical tunes and the accurate translation means that small differences in molecular structure can be distinguished by their tunes (Long L "Tuneful Proteins" New Scientist 2001:53, September 8, www.molecularmusic.com)

Proteins are 3-dimensional biological molecules that are conventionally described as having four levels of structure. Note sequences which reflect these differing levels of detail can be generated, and layering of such note sequences produced from a single protein produce protein-specific musical compositions. You could say that these compositions are "multi-dimensional" as they

are describing many levels of a protein's 3-dimensional structure at the same time. This method of musical translation of 3-dimensional protein structure generates note sequences that sonically describe the visual features of the protein's structure. This means that rather than simply looking at a protein and seeing structural features, you can hear them. Such note sequences may act as an auditory aid in perceiving and visualizing protein structure. Humans' have a keen ear for musical patterns and this method of translating structural data into musical form facilitates the recognition of those patterns. This is a different way of looking at protein structures which are normally represented by complex visual models or data sets. Because it is more accessible, it opens up the area of molecular biology to a larger range of people who perhaps would not have access to it, for example in the case of children and the visually impaired.(Explore at-bristol exhibit www.molecularmusic.com; The Biochemist 2002,24(6):40.

Consider for instance, the importance of this for science as noted in the The Harrow Technology Report Haunting Melodies (2001 at www.theharrowgroup.com). There the report reads: "Dr. Long has come up with a way to map the intricate whorls and swirls of these "patterns of life" into a medium that is rich enough, and symbolic enough, to allow people to intuitively grasp and differentiate between the complex instructions that define how living things are put together. . . . ."Is this important?. . . I suggest it is very important indeed . . . . Because as we continue to develop enormously complex data sets in many fields, our ability to understand, and to make sense of this overpopulation of data, demands innovative new ways of looking at (or listening to) them. For example, if you play several of the sample music clips …. [referring to music derived from protein structures found on the molecularmusic web-site www.molecularmusic.com].you can easily tell the difference between them. But if you were shown the 3D models of the proteins, would it be so simple?" Simply put then, if Dr. Long's approach to molecular music can be so effective for thinking about complex structures such as proteins imagine how it could advance our appreciation of molecular transformation as relatively simple as the linked step-wise and cyclical reactions in glycoloysis, the Krebs cycle and the Electron Transport System.

Discussion: Internalizing and Externalizing

In a cross cultural study of time, The Dance of Life, by Edward T. Hall (1983: 165), he refers to and advances John Dewey's discussion in Art and Life (1934/1980) that the tie which connects art and science is a shared interest in rhythm. The importance of rhythm in the context of atomic or molecular time has not be substantially considered in biochemistry or developmental and molecular biology (see Newman 2007). Hall's discussion of the dimensions of creativity (internal versus external) is most relevant to our proposed learning machine. Hall writes: "The difference between creating inside oneself and creating outside by means of an extension is basic and crucial" (ibid.:140). For Hall, an extension is an "externalized manifestation of human drives, needs, and knowledge," for instance the telephone extending the voice, computers extending memory and the arithmetic mind (pp. 130). In the case of this proposed learning machine, it physically and conceptually extends the internal process of memorization. As Hall adds, while some people are more effective at working out conceptual problems in their heads, others have to externalize the operation and this is a much slower process (ibid.:139). For those students, the Dance of Life could be particularly helpful.

Hall introduces two directly relevant issues for this machine and learning the Krebs cycle: peoples' abilities to internalize and externalize concepts and peoples' abilities to distinguish between sequential and discrete units (1983:140). As he notes, "The artist or scientist who sees a complex form all at once will have fewer problems externalizing or translating into symbols than the individual who has to tease his product into bits and pieces, externalizing something without form from his unconscious which he then assembles outside his body on paper, canvas, clay or a dance floor" (ibid.). Hall adds an additional point of relevance to the potential value of this experience in his observation that some individuals are able to span time more effectively, that is, to think into the future. Such individuals are able to hear where a musical composition is going, as Hall states "they experience what is going on in the present as a portion of a unified entity that is played out in a sequential manner (ibid.:139). They are therefore more easily able to visualize, commit to memory, and conceptually manipulate the sequential steps involved in complex cyclical and non-cyclical biochemical reactions.

In The Dance of Life experience, the participant would enter into a sublime zone of wonder relating to the inner workings of the mitochondria. An artist such as Dale Chihuly could likely achieve the required effect, as for example with the blown glass ceiling exhibit in the Indianapolis Children's Museum. And a musician such as Lori Anderson would likely be able to assist in the direction of the musical materials because of her iconic piece "Big Science" and her appointment as a NASA artist. In Indonesia, artists, musicians, and directors such as Nia Dinata, Jay Subyakto, and Ananda Sukarlan have similar world class capacities. Whatever artistic collaboration eventuates, students will find their rhythm through the power of image, color, and music, all of which will have to be carefully designed, composed and integrated for synesthetic effect and signaling precise molecular transformations.

Engaging all their senses, repeating, going backwards and forwards as needed, or even skipping steps, slowing down or speeding up, going around and around, will help learners automatically internalize their own inter-connected sense of the complexity of molecular transformations that take place in the Krebs cycle. In his discussion of the organization of energies through rhythm and repetition (1980:62-186) John Dewey draws on Coleridge's thoughts on the imagination and refers a synthetic aesthetic experience: "the welding together of all elements . . . . into a new and completely unified experience" (ibid.:267) which we propose as the overall artistic goal of our experiment.

The simultaneously internalized and externalized rhythmic multi-sensory experience involves a different mode of learning science than currently is practiced. The experience will differ in terms of the cognitive process and the traditional psychology, hierarchy, and structure of learning. Fusing biochemistry and molecular biology, it will bring together different brain and body functions, creating a unique learning synergy. This would allow individuals to draw upon their innate cognitive strengths, whether they are more analytic or synthetic. Novel scientific insights might result because learners will be able to more imaginatively engage molecular structures and transformations in motion, both as individual steps in the cycle and as part of the full cycle. In this fusion of the objective and the subjective, the internal and the external, conscious and unconscious connections will form. The sequential steps, the inputs and the outputs, the rhythmic integration of this knowledge, will ideally ignite a passion for science through communicating the sheer wonder of how it progressively renders the invisible visible, the formerly untranslatable

translatable. There is potential here for a love affair between art and science with nearly unlimited reproductive potential.

It remains then to conclude by turning to Punt (2012) and Malina (2012) on science and the sublime. Punt points out that in the process of externalism, "materials and objects are always implicated in our cognitive architecture rather than being simply outputs of our internal cognitive processes. There, in the scientific quest to makes the un-observable observable, "[T]hinking through objects rather than thinking about objects becomes the description of the cognitive process." In the same context, Malina, highlights science art projects which are succeeding at generating a sense of the sublime while contributing to science, such as musical compositions based on scientific data, multi-modal representations of hydrogen atoms through visualization and sonification, and immersive fly through scientific experiences with sensual and emotional power. Here we find evolving arts-sciences practices. This proposed SEAD collaboration (as a cognitive extension device) intends to engineer a space for stimulating the relation between memory and attention. The experiment would connect the conscious and subconscious mind through an aesthetic learning experience linking the objective and the subjective in a creative dynamic.

With an internalized sense of the dynamic dialectical whole, complexity, and homeostasis (Levins and Lewontin 1985), the horizon for science education and research practice can potentially be expanded in new dimensions. New questions may surface about synergistic rhythms, oscillatory molecular dynamics, and the evolutionary molecular transformations involved from prokaryote to eukaryote with the emergence of the mitochondria (Woese 1998). Towards unchartered territory then, the goal of The Dance of Life is to establish a dynamic template within the conscious and unconscious mind, ideally resulting in a sublime art-science experience (Hoffman and Whyte 2011, Malina 2012, Punt 2012, Sarrukai 2012).

Suggestions from Helen-Nicole Kostis, Science Vizualization Lab, NASA

1. Dr. Kostis, in her review of this paper, made a number of suggestions as follows. They are mainly posed as questions and ideas for expanding the potentials the machine and experience appears to offer. Again, as with the collaboration with Dr. Linda Long and Kathryn Trenshaw, the hypothetical experimental learning machine seems to be capable of generating substantial potential synergy for teaching and learning science.

2. How would the installation work with multiple participants? How can The Dance of Life machine take advantage of this? What will change in the environment (except visuals and sound)? How can this affect the process of the machine? How can this benefit the machine? For example: Can multiple processes be instantiated? Can this increase the speed of the cycle? How can this be linked to benefit science?

3. What other forms can this project take considering that it could be a powerful installation and learning experience, in a science center? The question then becomes: how many people will be able to experience it in a museum? While the numbers could be substantial, is it possible to create additional forms of this project? For example, what are the potentials for mobile development, that is, the sort of game where users can either

experience it alone or with other users? If that were possible, then the project would become available to a huge audience.

4. It could also possible to build this project in a reverse manner and by basing the project more explicitly in Self Determination Theory. If that were the case, then it would become a more complex and much larger project with even greater benefits. For instance, one could create a system/engine that could be programmed based on Self Determination Theory that followed general rules. It could accept the following components in generic modes, namely visualization modules, sound components and interactivity. Then one could use The Dance of Life to teach the Krebs cycle as an example of use in which rules, modules, components and interactivity could be refined in detail on the system. For this type of project one would need at least 3-4 more examples, as suggested already perhaps for learning the Periodic Table and the Calvin cycle or even multiplication and division. In this scenario, the proposed machine mediated embodied learning model would provide a system that can be significantly expanded and which has potential in education far beyond bio-chemistry. That would interest other institutions or partners outside of science centers as they would be interested in its development in terms of how they would benefit from it.

References

Bohannan, John. "Can Scientists Dance?" Science 318 (2008): 905.
, C. Immersive Virtual Art and the Essence of Spatiality. Toronto: University of Toronto Press, 2007.
Dewey, J. Art as Experience. New York: Perigree Books,1934/1980.
Long, Linda. Tuneful Proteins, New Scientist, September 2001 ; also www.molecularmusic.com for music samples and further information on how the music sequences are generated
Hall, E. T. The Dance of Life: The Other Dimension of Time, New York, Anchor Press, 1983.
Hanna, J. L. To Dance is Human: A Theory of Nonverbal Communication, Chicago: The University of Chicago Press, 1987.
Klahr, D. Exploring Science: The Cognition and Development of Discovery Processes. Cambridge, MA: MIT Press, 2000.
Malina, R. "A role for the Sublime in Art Science: Is the Sublime Important in Science Today?" Leonardo Reviews Quarterly 2.01, July, 2012. www.amazon.com/dp/B008JG7DAM
Punt, M. "Science, History and the Sublime." Leonardo Reviews Quarterly 2.01, July 2012. www.amazon.com/dp/B008JG7DAM
Safire, W. and J. Kagan. Neuroeducation: Learning, Arts, and the Brain: Findings and Challenges for Education and Research for the 2009 John Hopkins Seminar. In Dimensions, Special Issue Where Art and Science Meets, March/April 2012.
Sarrukai, S. "Science and the Sublime." Leonardo Reviews Quarterly 2.01, July 2012. www.amazon.com/dp/B008JG7DAM
Woese, C. "A New Biology for a New Century," Microbiology and Molecular Biology Reviews 68 (2004): 173-186.