

BEYOND THE FEED AND BOARD: HOLISTIC PRINCIPLES FOR
EXPRESSIVE WEB CURATION

A Thesis

by

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ABSTRACT

We develop holistic principles for expressive web curation through the iterative design and study of a new medium and system, *IdeaMâché*. Web curation is the process of gathering and assembling content into online exhibits. The linear organization of the feed—e.g., Facebook and Twitter—and board—e.g., Pinterest—constrains authors in expressing themselves.

We conducted a field study of *IdeaMâché* with 472 undergraduate student users. Quantitative, qualitative, and visual data show how students expressed themselves and developed ideas. Interaction logs show how students utilized expressive operations. We analyze students' creative works with ideation metrics of curation. Interviews expose users' underlying motivations and experiences. Visual data is compelling.

While iteratively designing *IdeaMâché* features in conjunction with the mixed methods data, we derive holistic design principles for media and systems supporting expressive web curation: direct clipping with context, diverse and heterogeneous media, freeform non-linear medium of assemblage, multi-scale organization, sketching as annotation, and novice-friendly direct manipulation command selection and parameter adjustment.

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1. INTRODUCTION

We develop holistic principles of web curation for supporting expression and creativity, and a new medium and system that manifests these principles. Expression and creativity are vital to human experience, promoting well-being [7] and economic innovation [47]. Digital curation is an extremely popular, everyday creative activity [37], through which people enrich their own and others' lives by collecting and sharing information. Despite their popularity [11], we find that prior web curation media provide limited capabilities for authors to express themselves and develop ideas.

Curation is the creative process of gathering, assembling, annotating, and presenting objects to form meaningful exhibits, for people to experience and think about. Central to curation is Duchamp's method of choosing found objects, shifting their contexts, annotating, and thus transforming meaning [39, 33]. Curation processes and products support people in *information-based ideation*, i.e., open-ended creative tasks and activities in which users generate and develop new ideas while interacting with information [33]. Thus, *web curation* refers to processes and products through which people consider, learn, conceptualize, reflect on, interpret, synthesize, ideate, and re-present information and concomitant ideas online. This research takes the position that human expression is inherently valuable in our experiences of information. Therefore, support for expression in everyday media and systems of web curation, and understanding of how these media and systems promote creative ideation, are imperative.

We consider structural relationships between media and systems. Media of expression are characterized by the sensory forms that people experience in creative processes and products. All such media are deeply linked to systems that enable



Figure 1.1: *Stages of Love*, web curation authored by a student in the medium of information composition of rich bookmarks, using IdeaMâché. The author explained, “We were having a girl’s study night . . . my roommate had just ended her relationship with her first boyfriend . . . [this shows] the break up stage and finding someone new.”

authoring and delivery of content [13]. In this way, a web curation experience is structurally characterized both by its medium and by the system that supports it. For example, the social medium of Facebook is inexorably linked to its system, including the cloud, ad placements, and web browser and mobile clients.

Structurally, a medium of curation can be understood through two levels: the representation of individual elements and that of the assemblage of the whole [33]. The medium of elements defines how individual underlying digital objects can ap-

pear and be interacted with. The medium and affordances of assemblage define the format and methods through which elements can be put together and combined. For example, Pinterest, Twitter, Facebook, and Zotero are experienced through their media for elements (Pin, Tweet, post, article) and assemblage (board, feed, library).

This paper develops holistic principles of expressive web curation through the deployment and study of a new medium and system, *IdeaMâché* [free to use at <http://ideamache.ecologylab.net>]. *IdeaMâché* explores expressive web curation by supporting freeform assemblage of heterogeneous elements in a nonlinear, multi-scale representation: information composition. The medium of individual elements is the enhanced web clipping, or *rich bookmark* [64]. A rich bookmark consists of an image, text, or video clipping, enhanced with metadata, enriched by contextual metadata, including the URL and title of the source document. Rich bookmarks can contain further structural metadata, such as a paper’s journal title, authors, references, and citations. This medium of assemblage, *information composition*, enables the visual manipulation of elements through transformations such as position, scale, rotation, layering, and blend [33]. It affords representing a curated set of rich bookmarks as a visual semantic connected whole. The medium of information composition is designed to promote creative cognition of relationships among curated clippings and annotations [33].

We conducted a field study, in which *IdeaMâché* was used on assignments in an introductory, interdisciplinary undergraduate course that teaches creative thinking and entrepreneurship. Students created curation products to perform open-ended creative tasks by clipping, organizing, and annotating media from the Web. The field study ran for three semesters. Some curations were personal (Figure 1.1), while others represented student innovations.

We begin by motivating our holistic approach to curation, expression, and cre-

ativity. We connect our research to related work across fields. We develop a survey of the web curation media landscape. We provide a walkthrough and description of the medium of information composition of rich bookmarks, as manifested by the IdeaMâché system. We present and analyze data from the field study, comprising 472 students users, addressing creative products through ideation metrics of curation and processes through logs of operations. We develop holistic design principles for supporting expressive web curation: direct manipulation rich clipping, diverse and heterogeneous media types, freeform medium of assemblage, multi-scale organization, sketching as annotation, and novice-friendly direct manipulation command selection and parameter adjustment. Our discussion calls out to publishers and tool makers to do little things that can make a difference in support for expressive web curation.

2. EXPRESSION IS HOLISTIC

A range of researchers and artists have articulated how the act of creative expression is holistic. Creative expression comes from diverse abilities and experiences. Cognitive abilities, knowledge, physicality, and technical skill work in conjunction. A holistic view of creative expression underlies our derivation of design principles for web curation, conjointly addressing media of curation and systems that supports them

Creativity comes from a combination of everyday abilities such as conceptual thinking, perception, and self-criticism [8]. Cognitive abilities work together to create insight and solve problems. Creative expression draws on all of a person's knowledge. Both domain knowledge on specific topics at hand, and knowledge from other domains, have the potential to stimulate insight [17]. The act of expression is not limited to a subset of cognitive abilities. It is not confined to a particular portion of memory and experience.

Creative expression is not just mental, but physical as well, involving physical motions and forces. Mind and body work in unison during creative tasks [12]. There are the specific physical actions associated with the medium and system currently in use, but creative insight could come from seemingly unrelated motions.

The act of creative expression extends beyond one's own mental and physical experience to include the media and systems that enable the expression. The medium is the combination of components that make up the final expressive product. The system is the environment and tools that enable the act of expression. Thus, *any expressive medium and the system that enables it are intrinsically connected* [13]. For example, oil on canvas is a medium of a painting. Its concomitant system encom-

passes paints, brushes, palette, easel, and lighting.

Constructivist artist and professor Moholy-Nagy articulated the importance of instructing designers and artists on the fundamentals of relevant technologies and materials [45]. He taught that creative expression is a result of understanding and connecting needs and means. Technology and art work together to attain fullness of expression. Thus, expression is holistic. It encompasses each person's own particular mental and physical abilities and the technologies and materials of expressive systems.

3. RELATED WORK

We combine a holistic outlook on creative expression with recent related work from human computer interaction. We look at prior techniques for gathering information in the form of clippings. We examine the connections between summaries, metadata, and exploratory browsing. Finally, we present prior work on different forms of spatially organized information.

3.1 Collecting Clippings

By *clipping*, we mean the act of selecting content to be collected in a source context, and bringing that content to an assemblage context. Hunter Gatherer [55] and WebSummaries [15] also address collecting clippings. They utilize a modal approach to clipping selection, which we call *click-select-collect*. The click-select-collect clipping technique is defined by its three stage process. First, the user *clicks* a button or keyboard shortcut to enter a clipping mode. Second, the user *selects* the desired content, either on the web page itself or from a generated list of potential clippings. Third, the user *collects* the clippings into their curation environment via another button press or keyboard shortcut, thus ending clipping mode. PiggyBank [25] enables collecting metadata for a whole page at a time, but not selecting elements within web pages, giving users limited control. Clui combines automatic metadata extraction with direct manipulation content clipping but only for limited sources [51].

Hunter Gatherer supported clipping content from within web pages [55]. As users activated clipping mode, each collected item was associated with source URL and title. This supported re-finding clipped content from a list. In a study comparing the application to copy and paste, they found people rarely add source page URLs of clipped content manually.

In Web Summaries, users browse a web page, activate a mode, then select a clipping from the page [15, 14]. The location of the selected content in the Document Object Model of the page functions as a template for collection of aligned clippings from similar pages.

Recently, Clui presented a technique that combines automatic metadata extraction with user-driven content selection [51]. They predefine “rich objects” on web pages and present them with handles. Users collect rich objects by drag and drop into a separate work space. However, curation elements can only be clipped from pages where rich objects are explicitly supported, not from the Web at large.

3.2 Exploratory Browsing Interface for Presenting Typed Metadata

A holistic approach is predicated on the value of making connections across elements. Qu et al introduced *exploratory browsing interfaces* to enable showing the connections between web pages. This approach is based on the notion of summarizing each web page, so that exploratory browsing interfaces can present multiple pages at one time, and imparting consistency and layering into presentation, to help users read and understand. Exploratory browsing interfaces must be dynamic, in that they must enable navigation through links and citation chains that the user serendipitously encounters.

Summaries enable users to see associations among ideas constituent in documents by reducing the information of each, enabling more documents to be shown and connections among them to be seen. *Metadata* is an effective means for summarizing web pages [15]. Qu et al developed a metadata type system, which enables specifying fields and associations required for salient summarization of particular kinds of information presented through the web, such as products, articles, and people. They extended meta-metadata, a language for describing, in an integral manner

both friendly to programmers and conducive of human-centered experiences, the data structures, extraction rules, and presentation semantics of types of information, in association with particular web sites and templated web pages [30].

The Metadata In-Context Expander (MICE) is an example exploratory interface in HTML5 developed using the meta-metadata type system [53]. MICE was also integrated into the IdeaMACHE system, activated when the user brushes a clipping. Presentation semantics are defined in the type with the metadata, itself, to improve legibility and interaction. To help users finding meaning in large amounts of information, presentation semantics enable ordering fields, hiding fields, using one field as the link for another, and specifying which CSS class to use to style a field. MICE enables *exploratory browsing* by using types to recursively expand linked information.

3.3 Spatial Organization of Information

Spatial hypertext enabled elements to be flexibly organized by users in 2D space, using features such as size and weight [42, 46]. In spatial hypertext, each element was typically plain text, lacking the URL of a bookmark, and so did not directly support re-finding. Thus, spatial hypertext advanced information organization in the abstract. However, a gap remained, as people organizing web information for re-use require portability, persistence, ease of access, ease of maintenance, and ease of sharing [27]. Thus, spatial hypertext, a precursor, defines a medium for organizing information, without addressing curation, *per se*.

Information composition extends spatial hypertext by emphasizing the visual and re-finding [29]. Composition adds emphasis on images, layering, and blending to spatial hypertext's flexible 2D medium of assemblage. From the start, information composition constituted a medium of curation, in that elements typically included source URLs and so afforded re-finding. The medium of information composition was

found to improve navigation while browsing a collection of web pages, as compared to linear text [31]. Composition was subsequently found to improve creativity during open-ended tasks through a field study of students [29] and a laboratory study [32], and to contribute to phenomena of situated creative learning and distributed creative cognition [28]. Composition has been found to support information-based ideation [33].

Webb et al extended information composition by using rich bookmarks as the medium of the elements of curation [64]. Composition of rich bookmarks was found to support reflection and interpretation during information-based ideation. We build on Webb et al's work through a browser and cloud-based system for expressive web curation, which provides ease of access, maintenance, and sharing.

4. WEB CURATION LANDSCAPE

We survey media and systems used for web curation. The *web curation landscape* includes a range of popular curation media/systems, as well as IdeaMâché. An exhaustive survey is beyond the scope of this article.

Lindley et al. previously compared practices of archiving personal content across disparate websites e.g., Flickr, Gmail, and Pinterest [38]. They found that a unified archive would not adequately meet user needs for personal web information management. Individual web media elements derive meaning from the contexts they are collected in, and lose meaning outside of those contexts. The present survey maintains their emphasis on context, but moves focus away from ‘archiving’, which denotes long term storage and infrequent retrieval.

Curation, in comparison, involves selecting, looking after, and presenting objects, for oneself and/or for others, in exhibits [49]. It is a process of contextualization [48]. The *exhibitive* aspect of curation means that is performed with the intention of imparting or communicating. Specifically in *web curation*, the media of elements and the medium of assemblage must directly involve the Web.

4.1 Axes of Analysis

We develop a set of essential and distinguishing axes for analyzing prevailing media and systems of web curation. We compare prominent web curation media/systems, and our own across these axes (Table 4.1). We explore how, individually and together, salient media characteristics, system features, and practices of adoption impact user experiences of curation.

4.1.1 *Gathering Technique*

How are elements of content gathered into a curation? The gathering technique is central to the curation experience. We identify four gathering techniques: manual, click-select-collect, drag and drop, and embedded.

1. Manual gathering involves typing out the link to chosen content or copying and pasting the link into the curation space. This is the most basic gathering technique; it is typically supported by most curation systems. Twitter is the only curation system in our landscape that only supports this method. While it is possible to drag and drop a link into the ‘Compose Tweet’ input box, we do not consider it to be drag and drop, because it is only a plain text transfer. No other contextual data provided.
2. Click-collect is our name for gathering the representation of an entire web page (Section 3.1). Users click a button provided by a browser extension or bookmarklet. They are presented with a preview of the curated representation and then click again to complete this gathering operation.
3. Click-select-collect is our name for the indirect, modal means of gathering of clippings (Section 3.1). Users (a) activate a clipping mode (click), (b) select the content from a set of possible clippings (select), and then (c) confirm their selection to complete the process (collect). Click-select-collect clipping is generally enabled via a browser extension or bookmarklet.
4. Drag and drop is a direct manipulation technique for continuously (1) selecting content from a source page, (2) dragging it to a curation space, and (3) dropping it into the context of the curation.

5. Embedded clipping is when a content provider places a button in context to enable the clipping of a predefined object. Facebook, Twitter, and Pinterest are commonly supported via embedded 'Share' buttons. These buttons create “rich objects” in a way similar to that of Clui [51]. The proliferation of embedded clipping buttons is linked to the popularity and everyday adoption of curation systems. We do not report on embedded clipping as a technique for curation, because it is implemented by content providers, not by curation systems.

4.1.2 *Media of Elements*

The types of media of curation for elements supported by a system determines look, feel, and potential uses. Common types of curated media include: image, text, and video. Our notion of image is based on the underlying IANA media type [26], including static as well as animated images. Text includes plain or styled text, but not text in form of an image. This differentiation is important when looking at Pinterest. Pinterest curations can include textual information only when these are represented by images. These text images can not be indexed, searched on, or created within the Pinterest system. Video elements in popular media are typically represented via players embedded from external sources, such as YouTube. The Zotero and Mendeley curation systems are specialized for scholarly references. They represent scholarly references as text. However, other forms of text cannot be incorporated, which is why we differentiate these from more general *text elements of curation*.

4.1.3 *Media of Annotation*

Does the curation system enable annotating? If so, in what forms, such as text or sketch? We consider comments and captions to be text annotations, as they typically describe and provide exposition for an element of curation. We distinguish between being able to annotate the curation as a whole, such as annotations which span

multiple elements of curation, and only being able to annotate within an individual element, which we signify with the label ‘elemental text’.

The forms of sketch annotations can be limited. Polyvore enables users to choose from a predefined set of shapes, but does not support free sketch annotations. Popular shapes include boxes and arrows.

4.1.4 *Metadata Browsing*

What amount of metadata does the medium and system support? *Limited* metadata means that a medium only supports metadata from a limited set of sources. Zotero and Mendley only support scholarly reference metadata. Polyvore only supports metadata from a predefined set of style and fashion clippings. *Static* metadata is flat, only providing the metadata for a single document. *Explorable*, on the other hand, includes the metadata for linked and nested documents which can be expanded and browsed.

4.1.5 *Medium of Assemblage*

What is the medium of assemblage in which elements are put together and exhibited? We categorize media of assemblage as either *linear* or *freeform*. Linear assemblages include lists, feeds, and boards. Lists can be in any order and often support on-the-fly reordering. Feeds are first-in first-out linear assemblages, typically resulting in chronological ordering of elements. As new entries are created, feeds are dynamically updated via prepend. Boards, while presented in a two dimensional grid layout, possess the same first-in first-out ordering as feeds. The present research develops a freeform non-linear medium of assemblage as an alternative to the rigidity of the feed and board. In freeform assemblage, curators define the spatial relationships among elements.

4.1.6 *Exhibitive*

How exhibitive is a curation medium? By exhibitive, we mean how easy is it to share curations and to what extent are the curations used to communicate? Curations in *open* systems typically become public automatically, making it easy to share with others. *Limited* systems enable sharing curations, but do not provide a means for browsing or discovering other curations. Evernote and Onenote are limited systems, in that they support sharing curations, but only through another communication medium such as email. *Private* systems do not intend for sharing curation at all, rather they are meant for personal use.

4.1.7 *Use Contexts*

Our final axis of analysis addresses: what are common use contexts for a particular curation system? Use contexts emerge as a result of different interactions supported by a system, as well as through social and organizational relationships. We define *everyday* systems as those frequently used for a range of personal, social and professional activities, by individuals, groups, and organizations. This daily usage is made possible by the wide range of interactions and features supported and by the reach of their adoption. *Personal* systems are used for the same tasks, but typically only by individuals and at a smaller social scale. Our selection of curation systems includes a few system with specific personal subtypes. Polyvore is focused on personal style curations characterized by an emphasis on fashion, furniture and other style related content. IdeaMâché is currently used primarily for educational purposes; most users are performing assignments in various university courses. Scholarly systems are specifically used for academic and research endeavors, designed to assist in the collection and organization of scholastic works.

The web curation landscape is continuously evolving. As new systems emerge

and current systems continue to change, this table will need to be updated.

	Gathering Technique	Media of Elements	Media of Annotation	Metadata Browsing
Facebook	drag and drop	video, image, text	elemental text	static
Twitter	manual	video, image, text		static
Pinterest	click-select-collect	video, image	elemental text	static
Tumblr	click-select-collect	video, image, text	elemental text	
Evernote	drag and drop	image, text	text	
Onenote	drag and drop	video, image, text	text and sketch	
Mendeley	click-collect	scholarly reference		limited
Zotero	click-collect	scholarly reference		limited
Polyvore	drag and drop	limited image	text and shape	limited
Prezi	drag and drop	video, image, text	text and sketch	
IdeaMâché	drag and drop	video, image, text	text and sketch	explorable

	Medium of Assemblage	Exhibitive	Use Contexts
Facebook	linear (feed)	open	everyday
Twitter	linear (feed)	open	everyday
Pinterest	linear (board)	open	everyday
Tumblr	linear (board)	open	personal
Evernote	linear	limited	personal
Onenote	linear	limited	personal
Mendeley	linear (list)	private	personal (scholarly)
Zotero	linear (list)	private	personal (scholarly)
Polyvore	freeform	open	personal (style)
Prezi	freeform	open	personal
IdeaMâché	freeform	open	personal (education)

Table 4.1: Distinguishing characteristics of media / systems in the web curation landscape. When the value of an axis is ‘not supported’, the entry is left blank.

5. SCENARIO

We describe our first author's process of authoring a curation of scholarly work related to this article (see Figure 5.1). Nic begins, as every IdeaMâché curation begins, by using the web application to open an empty canvas in a browser window. The acts of choosing, assembling, organizing, and presenting transform the empty canvas into a curation.

In a separate window, Nic performs a web search for scholarly articles related to information clipping and zoomable user interfaces. He browses results, surveying titles, authors, and abstracts for relevant research. He comes across work by Perlin and Fox and chooses to collect an article on Pad [50]. From the source web page, he selects an image of the system and simply drags and drops it onto the curation canvas. Once dropped, IdeaMâché transforms the image into a rich bookmark representing the article.

Nic brushes the newly created rich bookmark to browse its associated metadata. The metadata for this scholarly articles includes the authors, categories, references, and citations. He expands and browses the metadata in context. Exploring the citing articles, he encounters subsequent work by Bederson. He finds an article about Jazz [6] and wishes to add it to his curation. Instances of other web pages in the metadata serve as links to the original web page. Using the link provided in the metadata, he browses to the source page for the article on Jazz. From this page he drags and drops an image of Jazz onto the curation canvas. Nic continues the process of choosing, dragging and dropping content from web pages into the canvas. He explores metadata to chain citations and references, as he assembles significant curation elements.

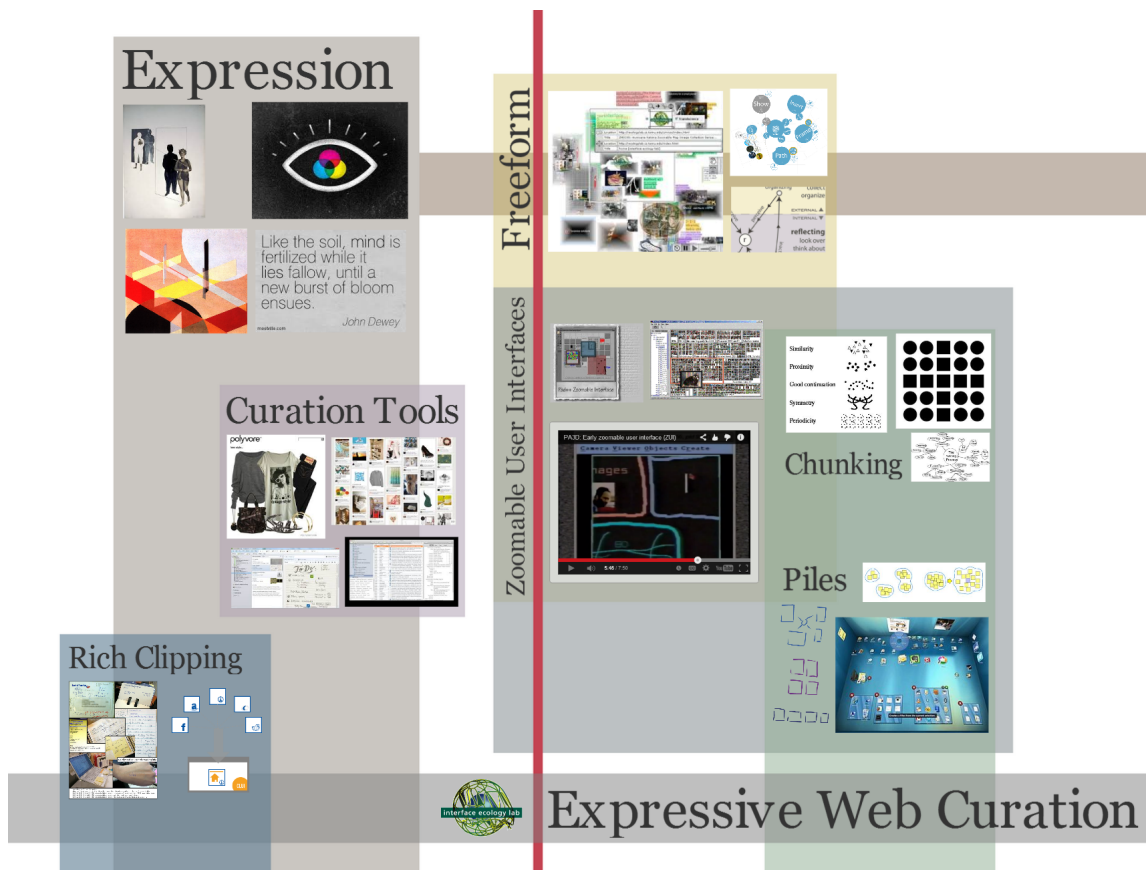


Figure 5.1: *Expressive Web Curation*, a prior work curation on motivations and related work on the subject of expressive web curation, viewable online at: <http://ideamache.ecologylab.net/e/D3F9Q9Gqjz>

Nic begins organizing the rich bookmarks into thematic clusters. At first, the clusters are messy, but as the process of collection slows, he spends more time arranging the elements to begin making them legible. Nic adds text annotations to explicitly label the clusters. Reflecting on his curation, as it starts to take shape, he realizes that he is lacking motivation for the importance of expression. He curates some from the art world focused on the concept of expression and its relationship to artistic mediums, specifically John Dewey and constructivism.

Nic becomes satisfied with the collection he has gathered, and switches focus to assembling the composition. He rearranges rich bookmarks so that groupings are

clear and harmonious. He uses visual transformations of scale, rotation, blend, and layering to give more visual weight to important rich bookmarks. Smaller groups emerge from his initial messy groups. He creates text annotations to label the new groups. He reflects on the research about piles. He sketches out some rough ideas for different visual structures for representing piles. Inspired by a painting by the Bauhaus artist Moholy-Nagy [44], encountered during his search, he adds rectangles behind elements. He continues this visual style, paying homage to the artist.

At this point, he titles the curation and adds a brief description. He updates the social visibility setting so that others can view the curation online, but only if they have the URL. He sends the unique URL of the curation to his co-authors for feedback. Co-authors use the link to view and interact with his curation in their web browsers. Nic is satisfied with his curation for the time but leaves the curation canvas open in the background. As he continues his research, he serendipitously encounters new sources, which can easily be added to this curation in progress.

6. IDEAMÂCHÉ: CURATION MEDIUM AND SYSTEM

We designed the IdeaMâché web curation medium and system to support expression and creativity. IdeaMâché enables users to *assemble* content using *direct manipulation of clippings* to reduce cognitive and neuromuscular load. This load reduction frees users to be more expression and creative. The system automatically captures each clipping’s context in the web. The resulting *rich bookmarks*, IdeaMâché’s medium of elements of curation, support re-finding and exploratory browsing of metadata summaries. The *medium of assemblage* is information composition, which enables freeform, nonlinear, holistic arrangement of elements. This promotes creative thinking about the relationships among curated elements. In order to scale the number of elements that users can organize and present, IdeaMâché employs a zoomable user interface. This enables *multi-scale information composition*, supporting organizing curated elements on and across multiple levels, extending the tradition of the Eames’ Powers of Ten [16].

This section illustrates how components of the IdeaMâché system enable users to engage in this holistic multi-scale information composition medium of curation. IdeaMâché addresses the curation lifecycle from start to finish, spanning: choosing, organizing, annotating, and presenting. We connect components in an overall web curation system and experience architecture (Figure 6.1). To constitute an expressive medium of web curation, the architecture integrates a *web browser extension* which transforms all information in the browser into content that the user can gather as rich bookmarks, a *zoomable curation canvas* for authoring and viewing curations, and a RESTful *cloud storage* service that manages and hosts users’ curations.

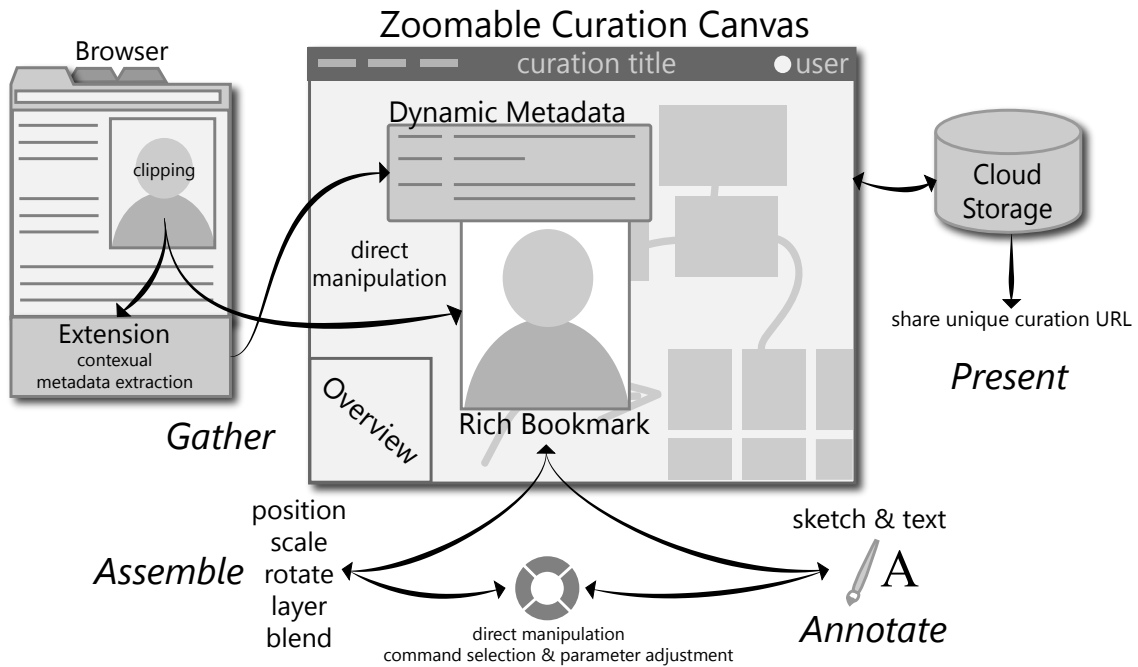


Figure 6.1: The IdeaMâché system supports the whole curation lifecycle: choosing, gathering, assembling, annotating, and presenting. Users *choose* content from the web browser and *gather* it via drag and drop onto the curation canvas. The browser extension forms rich bookmarks, adding explorable metadata to clippings. The control menu enables direct manipulation command selection and parameter adjustment of element visual transforms, supporting *assembling*. Users *annotate* using text and sketches created with the control menu. The overview shows the curation as a whole to support navigation. The curation saves to the cloud enabling easy access and *presentation*.

6.1 Browser Extension: Gather Clippings as Rich Bookmarks

IdeaMâché enables users to choose and gather content from web pages, in the form of clippings as rich bookmarks, using direct manipulation. The clipped content may be text, image, sound, or video. The browser extension automatically acquires contextual metadata as the user clips content. A rich bookmark is formed by attaching the contextual metadata to the clipping. These rich bookmarks become the elements of curation. Once content is clipped, the user drags it onto the curation

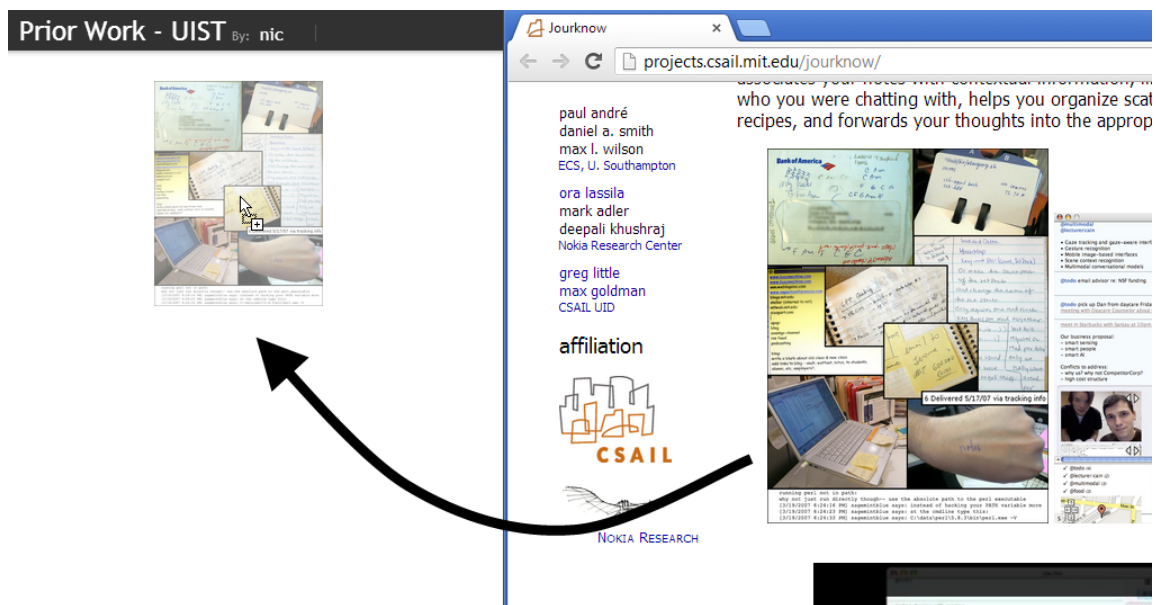


Figure 6.2: Images, text selections, and links are dragged from a web page onto the canvas to create a rich bookmark.

canvas and drops it there (Figure 6.2).

This clipping techniques contrasts with the prevailing web curation landscape. In Twitter, URLs for content must be typed or pasted into a text box, the source context is lost. Pinterest uses click-select-collect only of images and video, providing only the web page location, title, and space for the user to add an annotation to the element; text and sound are not supported as media for elements of curation. Facebook presently enables users to collect web pages, as a whole, with some context attached, or images without any context. Through use of a browser extension, IdeaMâché transforms the whole web browser into a curation environment, including curation canvas instances that the user situates in a few tabs and the other browser tabs in which she encounters meaningful content.

Contextual metadata is automatically extracted at the time of clipping using the meta-metadata type system (See 3.2). The meta-metadata runtime is invoked by

the browser extension to determine the correct metadata type for the current web page. For example, if the user selected the product image from an Amazon product, then the extension would assign the page the `amazon_product` type, and perform the extraction based on the rules defined in the Amazon Product meta-metadata. Contextual metadata includes as first class objects not only the metadata type of the source page, but also structurally linked pages. In this example, the contextual metadata would include, (1) the source product page, and (2) associated product pages such as ‘People Also Buy’ and ‘Bestseller List’. The type information is stored with the metadata. Presentation semantics from the metadata type will later be used when dynamically presenting the metadata to the user in the curation canvas.

In order to acquire contextual metadata for each clipping, when each web page is loaded, the browser extension injects a drag event handler. Upon the start of a drag event, the extension performs the contextual metadata extraction and association. The mechanism for this is the data transfer object that every browser drag event contains. Each data transfer object includes a set of alternative data representations, each assigned to a particular Internet Media Type [26]. Commonly used Media Types include `text/plain`, `text/html`, and `text/uri-list`. To the drag event, the extension attaches the typed contextual metadata and clipping as a serialized JSON representation. While we presently use the standard drag event Media Type, `application/json`, we advocate definition and assignment of a new standard type, `application/metadata+json`. When the user drops the clipping into into IdeaMâché, the JSON is deserialized. The Media Types available in the drag event and the contextual metadata type are used to determine the type of the resulting rich bookmark.

6.2 Zoomable Curation Canvas

Once gathered, elements of curation are assembled by the user into a meaningful exhibit. Assembly involves conceptualizing, organizing, arranging, designing, and composing. It is the formative act of putting the individual pieces together to create a whole that is more than the sum of its parts.

IdeaMâché gives the user an authoring environment, in the zoomable interface tradition of Pad [50], with an HTML5 [62] browser-based implementation reminiscent of Google Maps. Maps, we note is mostly not an authoring environment, but a viewer, which renders map tiles of a single format onto a background on which markers are placed. IdeaMâché’s zoomable canvas supports assembling multimedia rich bookmarks of diverse types into expressive web curations.

When the user drops a clipping, after determining the rich bookmark’s type, including the clipping and metadata types, IdeaMâché positions the rich bookmark in the zoomable curation canvas, chooses an appropriate scale, and renders it. The initial scale of an element is determined by the current scale of the main viewport.

We designed the canvas with both novice and expert users in mind. The curation canvas integrates interaction techniques including ZUIs, overview+detail, exploratory browsing interfaces, lightweight sketching, and control menus. We employ ZUIs and overview+detail techniques with the goal of helping users scale curation. Exploratory browsing techniques enable the user to follow links and engage in citation chaining [4] in the context of a curation. Lightweight sketching is used to enable the user to engage in visual thinking [1] and express connections among curated elements. A control menu is designed to support direct manipulation command selection and parameter adjustment for novice as well as expert users.

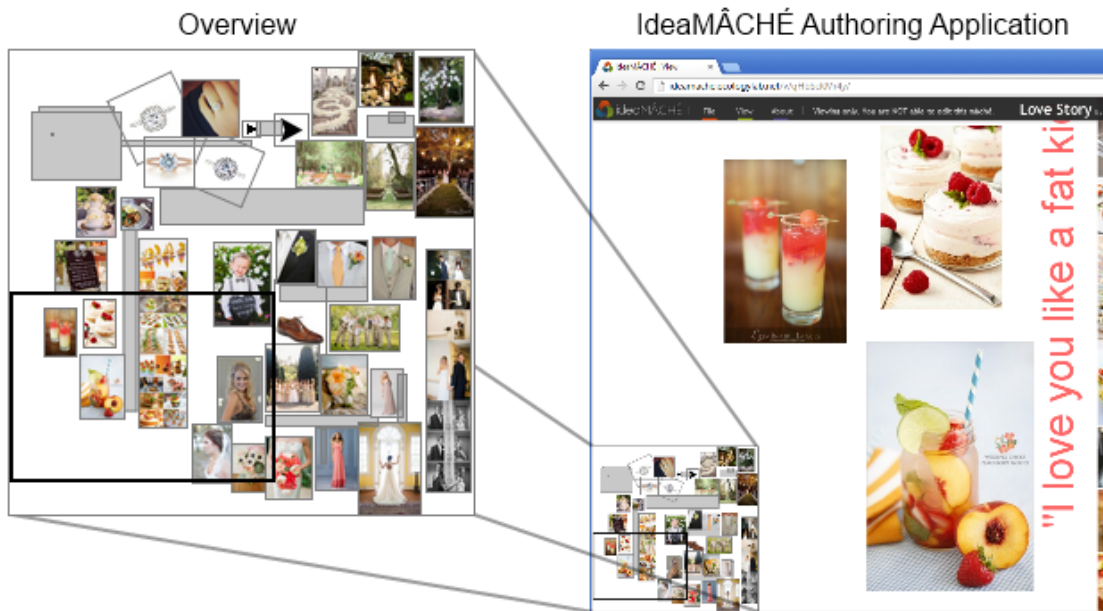


Figure 6.3: The overview, located in the bottom left of the canvas, provides a view of the curation as a whole and indicates the location and size of the main canvas viewport.

6.2.1 *Manipulate Viewport*

The zoomable curation canvas is a nearly infinite two dimensional plane. Width and height are not explicitly constrained. Users are able to pan indefinitely and arrange elements of curation as close or as far apart as they like. At the same time, all displays are finite. Within the nearly infinite canvas, users may wish to work at different levels of detail at different times.

Thus, the canvas is primarily viewed and interacted with through a ‘main viewport’. The main viewport can be repositioned using arrow keys or by pressing down the left mouse button on an empty area of the canvas and dragging. Users can zoom the main viewport via mouse scroll wheel or keyboard. The scroll wheel zooms the canvas in relation to the mouse position. The plus and minus keys zoom in relation to the viewport’s center. To manage web browser performance, while providing a good

level of multi-scale expression, we limit the minimum and maximum zoom range to 0.001 - 30.

To support navigating the canvas, IdeaMâché provides an overview (Figure 6.3) to compliment the main viewport. The main viewport shows the detailed view that the user has selected. The overview shows the whole curation and the position of the main viewport within it. This overview+detail technique has been shown effective for supporting navigation in ZUIs [24, 59]. It provides a visual navigation aid and enables repositioning of the main viewport. The overview is shown in the bottom left by default (but can be hidden). As the canvas grows and shrinks due to adding, removing, and repositioning elements of curation, the overview scales its representation to maintain a view of the whole curation. Clicking in the overview will center the main viewport over that location. A zoom slider indicates the current zoom level. The slider can also be used to manipulate the zoom.

6.2.2 *Visually Assemble Elements of Curation*

The curation canvas is designed to support the assembly of elements. Assembly involves organizing, arranging, designing, and composing. Composition is an artistic method of assembling elements to form a connected whole. Users are encouraged to manipulate the presentation of elements to juxtapose concepts and express emergent connections. There are no imposed layouts, templates, or borders.

IdeaMâché supports visual transformation of elements of curation. The elements of curation include rich bookmarks and annotations. Rich bookmarks, as previously defined, are clipped content from the Web with attached contextual metadata. Annotations are created by the user within the curation canvas and do not contain any metadata nor link to a source document. Annotations can be in the form of text or sketch.

All elements—rich bookmark and annotations—afford the same visual transformations. The user can freely manipulate position, scale, rotation, layering, and blend. Elements are directly repositioned by click and drag. Other transformations are performed through a control menu.

The control menu enables transforming scale, rotation, blend, and layering. Scale and rotation transformations are calculated around the center point of an element. Blend changes the opacity of an element allowing for elements to overlap and show through. Layer transformations enable users to position elements behind or in front of other elements. The control menu also supports cut and paste of elements and box selection, which enables users to operate on multiple elements at once. When performing transformations on multiple elements, the geometric center point of the selection is used as the center for scale and rotate transforms.

6.2.3 *Dynamic Metadata: Exploratory Browsing through Rich Bookmarks*

Rich bookmarks use *dynamic metadata*, which has been shown to effectively summarize source and linked web pages [53], allowing the user to browse chains of links without leaving the context of the curation. This metadata is presented inside a dynamic exploratory browsing interface, the *Metadata In-Context Expander (MICE)* [53]. MICE uses a metadata type system to summarize diverse web pages, including products, social media, and scholarly articles. Exploratory browsing interfaces assist the user in discovery by presenting multiple web pages and their connections. In the example (Figure 6.4), the metadata type is scholarly article. Activating any referenced document expands it, on the fly, recursively nesting the new metadata summary in context of the previous.

MICE is activated when the user brushes over a rich bookmark. MICE uses presentation semantics defined in the type with the metadata to dynamically generate

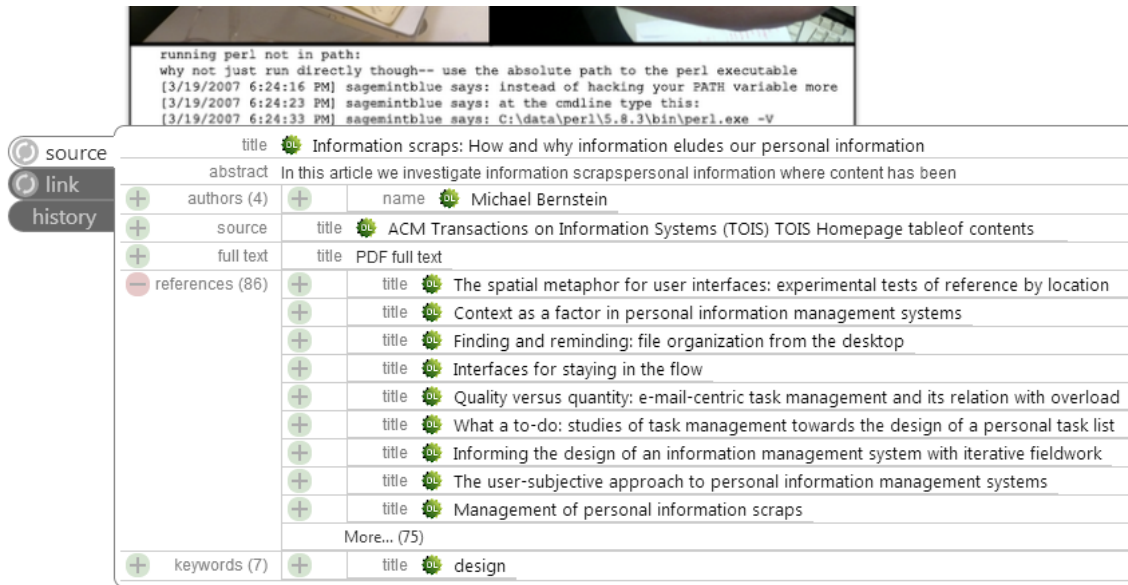


Figure 6.4: The Metadata In-Context Expander presents explorable metadata when brushing a rich bookmark. Example shows metadata for an ACM paper.

HTML5 elements. Presentation semantics enable ordering fields, hiding fields, and using one field as the link for another. Visually optimizing presentation grows in importance as more information becomes presented at once. The metadata can also be used for external navigation, showing the full web page in a new tab.

IdeaMâché enables associating a rich bookmark with multiple web pages. In addition to contextual ‘source’ metadata (see 6.1), ‘link’ metadata is generated if the dropped data transfer object contains HTML links to other documents. Further, users can drag and drop additional URLs onto an existing rich bookmark to add multiple document associations. A tab view of these associated source and linked documents enables the user to switch the metadata MICE presents. The example (Figure 6.4) shows a ‘source’ tab, containing metadata for the article’s digital library page and a ‘link’ tab which contains the metadata for the article’s linked PDF.

6.2.4 *Annotate*

Annotations enable exposition, which can involve labeling, explaining, expounding, and illustrating. IdeaMâché supports annotations in forms of text and sketch. Text annotations enable labeling the whole and subsets, to support explicit categorizing, as well as expression through writing. Sketch annotations enable expression through drawing.

Sketches and text annotation modes are activated through the control menu. Once created, annotations afford selection and transformation, like other elements of curation. The system supports basic text editing, styling and formatting.

To create a sketch, the user enters sketching mode via the control menu. In sketching mode, the mouse pointer interactions for the viewport and prior elements are disabled. The mouse pointer becomes a brush. Users can draw with any available input modality, such as mouse, stylus, or touch. Keyboard shortcuts can still be used to pan the viewport during sketching; however, the zoom level is locked.

In sketching mode, a control menu presents options for changing brush size, selecting stroke color, beginning a new sketch, and exiting sketch mode. Upon exiting sketch mode or when beginning a new sketch, previously drawn strokes are combined to form a sketch annotation. These strokes become permanently grouped together as a single element. The initial scale of the sketch element is determined by the current zoom level of the viewport.

6.2.5 *Direct Manipulation Command Selection and Parameter Adjustment*

We developed a novel integrated marking and control menu designed to support direct manipulation command selection and parameter adjustment (see Figures 6.5 and 6.6). Marking menus enable quick activation and selection of menu operations in a single action [34]. Regular marking menus only allow for non-parameterized

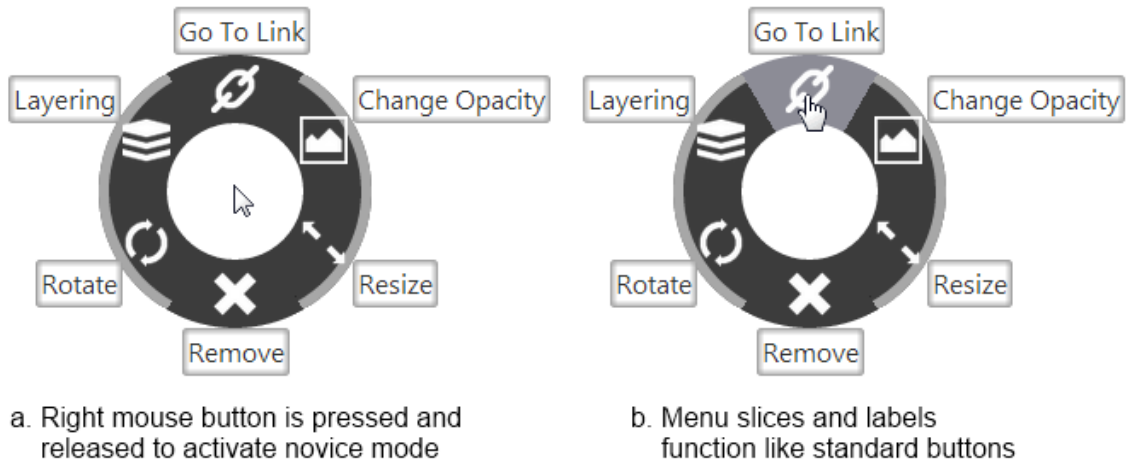


Figure 6.5: Novice mode of the control menu, accessed from expert mode.

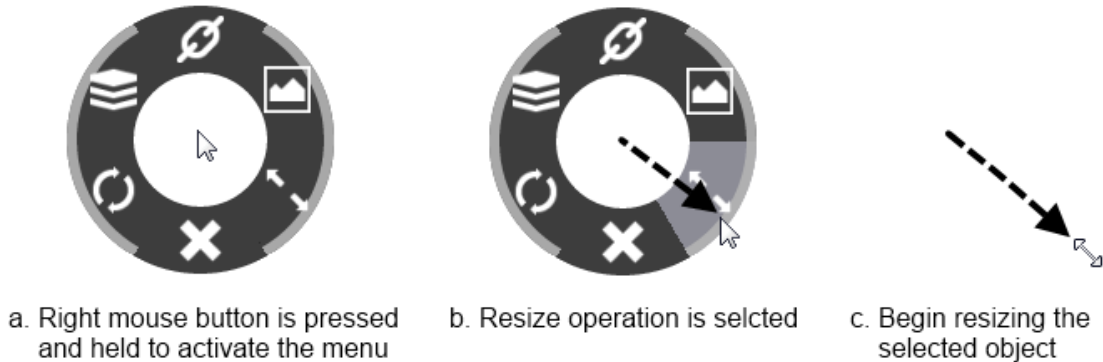


Figure 6.6: Expert mode of the control menu.

operations. Control menus differ from marking menus by supporting continuous parameter adjustment [52]. Users fluidly begin adjusting a parameter directly after selecting an operation. The distance the cursor travels after the operation is selected is significant; it defines the value of the parameter. Control menus have been shown effective for fast and accurate selection [23]. We designed the IdeaMâché control menu to be used by software novices and through use, teach them to become experts. The

menu includes a standard expert mode, similar to prior control menus, and a novice mode, similar to a radial menu, designed to scaffold learning and increase expert usage.

The IdeaMâché control menu is contextual, presenting different operation sets, depending on where and when it is activated. The four operations sets are: visual element menu, textual element menu, canvas (background) menu, and sketch menu. Only some menu operations are parameterized. Non-parameterized operations are executed directly. These include navigate to link, cut, paste, begin sketching mode, open text editing tools, and change brush color. Other operations require parameter adjustment, which is performed directly following operation selection. These include scale, rotate, blend, layer, brush size adjustment, and multi-select.

The menu consists of a clear inner circle, a gray ring subdivided into sections for operations, each containing an icon, and an exterior set of labels for the operations (Figure 6.5). The labels are only visible in novice mode. The distance from the center of the menu to the inner border of the ring is the *pre-activation* distance. The distance from the center to outer border of the ring is the *activation* distance. The light gray border on the outer rim of the ring indicates which operations are parameterized.

To open the menu, users press and hold the right mouse button. Users without a right mouse button can use the combination of the Control key and the left mouse button. Immediately upon opening, the menu appears, centered around the pointer. The menu begins in expert mode, without labels (Figure 6.6 a).

Novice mode is activated if the user releases the mouse button within the menu's clear inner circle (Figure 6.5). Labels for each operation appear. The user activates an operation by moving the mouse radially and clicking on its ring section or label. For parameterized actions, users drag a ring section or label to adjust parameters.

Novice users can ignore expert mode, using the control menu as a radial pop-up menu.

To use expert mode, open the menu but do not release the mouse button while within the clear inner circle of the menu (Figure 6.6). Moving the mouse radially past the pre-activation threshold, into a section of the ring, highlights and selects the operation (Figure 6.6 b). If the selected operation is non-parameterized, releasing the mouse button performs it (Figure 6.6 c). To avoid accidental activation, the operation stays highlighted if the activation threshold is crossed, but is only performed upon mouse button release.

For parameterized operations, moving the mouse past the activation distance selects the operation and directly initiates parameter adjustment. For example, once the scale operation's activation threshold is crossed, the pointer immediately begins adjusting the size of the selected element. Releasing the mouse ends parameter adjustment.

6.3 Present: Users and the Cloud

Presentation requires making a user's creative work accessible across the web. The IdeaMâché system is supported by a cloud architecture that handles user accounts and curation hosting. This essential aspect of Web 2.0 applications is expected by users. A basic capability is to enable users to log in and access their curations. The IdeaMâché system stores and retrieves curations through REST calls. The system supports the following calls: `user_info`, `composition`, `get_composition`, `put_composition`, and `event_log`.

The IdeaMâché presents state information and access to cloud-related operations to users in a header above the curation canvas. An indicator presents the current cloud save state of the curation. Changes are automatically saved to the cloud

every 12 seconds. Users can also click this save indicator to force a save. The title, description, and thumbnail for the curation can be set. Users are also able to set the level of social visibility: private, unlisted, and public. Private visibility restricts viewing to only the author's account. Unlisted allows anyone with the link to the curation to view it, but IdeaMâché will not display the curation on the front page of recent curations nor will it be search-able. Public curations will possibly appear on the IdeaMâché home page and can be publicly searched for. At this time, the IdeaMâché system does not support collaborative editing.

7. FIELD STUDY

We conducted a field study over three semesters in an introductory undergraduate course, *The Design Process: Creativity and Entrepreneurship* (DPCE). We will derive holistic principles for expressive web curation from this investigation of the use of IdeaMâché. Field studies provide insight about how technology is incorporated into real world contexts. While classroom field studies are subject to uncontrolled variables, comparisons across semesters have been shown to be ecologically valid [9].

DPCE students function as inventors and proto-entrepreneurs, creating concepts and sketches for new products, services, experiences, and art. They represent a wide variety of majors, including architecture, engineering, humanities, and business. In general, they are novice users of computing systems and interaction techniques.

Process and product are significant aspects of creativity [54]. We present data both on expressive curation products and the processes through which they were curated. We compare curations from the Imagine a Solution Curation assignment between semesters I and III and discover differences. We investigate the creative and expressive processes of students from semester III by examining operation logs. We also performed semi-structured interviews with a number of students from Semester I who created interesting curations, in order to understand their motivations and thinking.

7.1 Methodology

In each semester, we presented an introductory lecture about expressive web curation and the IdeaMâché medium and system. Students were assigned to use IdeaMâché to author an *Imagine a Solution Curation*. The assignment instructs each student to conceptualize, curate, design, explain, and reflect on a solution to a

personal need in her/his life. Submitted curations addressed various themes such as weddings, redecorating, *Stages of Love* (Figure 1.1), and workout routines. These themes are similar to those that arise in popular web curation media, such as Pinterest [37].

This paper presents data on Imagine a Solution Curation because this assignment was constant across semesters. Students used IdeaMâché for other assignments, which changed over the the three semesters. IdeaMâché was first deployed in DPCE in Spring 2013, Semester I. The initial implementation lacked some current features. For Semester II, Fall 2013, we added zooming, sketching, initial interaction logging, and support for more video clipping sources. For Semester III, Spring 2014, bugs were fixed and interaction logging was improved. For this reason, we investigate creative processes by examining Semester III interaction log data. The logging mechanism is built into the undo/redo history stack, using an approach similar to Grossman et al. [21]. These logs detail curation operations which include, elemental interactions, control menu usage, viewport manipulation, and dynamic metadata bookmark exploration.

7.2 Creative Product Results: Ideation Metrics of Curation

We collected 176 curation products from Semester I and 296 from Semester III. We compare student curations between semester conditions using *ideation metrics of curation* [33]. Ideation metrics of curation extend seminal work on measuring creativity by Guilford [22] and Shah [57]. Among ideation metrics are *Fluency* and *Flexibility*. Fluency refers to the number of ideas that people have. In the case of web curation, Fluency refers to the number of elements they gather and their annotations. The motivation comes from Darwinian theories of creativity: more elements provide more opportunities for survival and growth. Fluency can be measured in aggregate

		Image Clippings	Text Clippings	Video Clippings	Text Annotations	Sketch Annotations
Semester I	μ	22.3	1.2	0.1	6.4	
	σ	1.0	0.2	0.0	0.4	
Semester III	μ	23.3	1.8	0.7	12.4	5.7
	σ	0.9	0.2	0.1	0.5	0.4
	$p <$	0.47	0.059		0.00001	
	t	-0.7	-1.9		-9.5	

Table 7.1: Comparison of Fluency metrics from 472 *Imagine a Solution Curations*: 176 from Semester I and 296 from Semester III. Total Element and Text Annotation fluency show statistically significant increases via t-tests.

		Document Flexibility	Domain Flexibility
Semester I	μ	26.5	17.1
	σ	1.4	0.9
Semester III	μ	33.1	18.0
	σ	1.6	0.8
	$p <$	0.002	0.46
	t	-3.1	-0.7

Table 7.2: Comparison of Flexibility metrics from 472 *Imagine a Solution Curations*: 176 from Semester I and 296 from Semester III. Document Flexibility shows a statistically significant increase via t-tests.

and for specific types of elements of curation, such as image and text clippings. Flexibility refers to the number of categories of ideas, which means looking at a problem in a variety of ways. *Document Flexibility* refers to the number of unique source web pages among assembled elements of curation. *Domain Flexibility* refers to the number of unique web sites among assembled elements.

Tables 7.1 and 7.2 present ideation metrics of curation for the student assignments. Semesters I and III are compared using a t-test. Total Element Fluency

and Text Annotation Fluency show a statistically significant increase in Semester III. This means that, in Semester III, students gathered more elements of curation and created more text annotations than in Semester I. Video and Sketch Annotation Fluency cannot be compared, because these operations were not supported in Semester I. Document Flexibility increased significantly from Semester I to III. However, Website Flexibility did not increase significantly. Thus, submitted curations from the Imagine a Solution Curation from Semester III contain elements of curation from more diverse specific pages than those from Semester I, but not from more diverse web sites.

7.3 Creative Process Results: Expressive Web Curation Operations

In addition to collecting and analyzing data about creative products, we investigate student *processes* of curation. We present and analyze operation log data from Semester III, without comparison, to investigate how the IdeaMâché medium and system were used (Table 7.3). Students used the whole range of available expressive web curation operations. Data shows that students gathered clippings as rich bookmarks, explored dynamic metadata, annotated using text and sketch, manipulated the viewport of zoomable canvas, and used the control menu to visually arrange elements of curation.

We report on student engagement in the Imagine a Solution Curation assignment. One measure of engagement is the time students spent on the task. There was no minimum time requirement for the assignment, and assignments were evaluated on a simple credit / no-credit basis. Statistically, students chose to invest significant time. We calculate total time spent using operation log data, removing periods of inactivity which last 15 minutes or longer. Students in Semester III spent a mean average of 1.87 hours using IdeaMâché for their Imagine a Solution Curations. Of

	Gather		Annotate		
	Drop Clipping	Remove Element	Create Sketch	Create Text	Edit Text
Σ	17420	3856	26172	2292	7893
μ	58.9	13.0	88	7.7	26.7
σ	40.0	18.7	116	7.2	25.4
<i>ops/hr</i>	36.4	6.7	49	5.1	15.6
<i>% students</i>	99	92	92	94	98

	View		Arrange					
	Pan	Zoom	Position	Scale	Rotate	Layer	Blend	Multi-Select
Σ	67193	48965	56425	19208	2502	1560	1596	1070
μ	227	165	190	65	8.4	5.3	5.4	3.6
σ	222	228	174	63	13.4	7.7	10.2	6.3
<i>ops/hr</i>	125	86	107	36	4.8	3.0	3.1	1.9
<i>% students</i>	100	98	99	97	67	74	68	57

Table 7.3: Operation data from 296 *Imagine a Solution Curations* from Semester III illustrates the students’ expressive processes. Data shows the sum (Σ), mean (μ), and standard error (σ) of operations per curation. Also included is the number of operations per hour (*a/hr*) and the percentage of students that performed that operation at least once ($\% > 0$).

the 296 students in Semester III, 199 (67%) spent up to 2 hours on the assignment, while 97 (33%) spent over 2 hours.

Figure 7.1 tells a story that contextualizes direct creative expression with data, presents an exemplary student Imagine a Solution Curation, *Children’s Peter Pan Inspired Room*, in conjunction with quantitative expressive process data and curation product ideation metrics data. This student author utilized features such as zooming and sketching to create an expressive narrative through the curation, spanning multiple levels of scale. We present two views of the curation, and summarize its Fluency and Flexibility metrics, and interaction logs (Figure 7.1).

On average, students gathered a clipping from a web page by direct manipulation

	Image Clippings	Text Clippings	Video Clippings	Text Annotations	Sketch Annotations			
Σ	47	0	2	34	8			
	Gather			Annotate				
	Drop Clipping	Remove Element		Create Sketch	Create Text	Edit Text		
Σ	67	24		10	38	69		
	View		Arrange					
	Pan	Zoom	Position	Scale	Rotate	Layer	Blend	Multi-Select
Σ	534	643	729	250	15	19	28	24



Figure 7.1: In *Children’s Peter Pan Inspired Room*, clusters of elements are arranged around an image of a fictional map to inspire and plan a room renovation. We show quantitative metrics of both the product and the process, a view of the whole curation, on the left, and a close-up of a portion, on the right. The rich bookmarks represent 29 unique source web pages (Document Flexibility), encompassing art, toys, furniture, and do-it-yourself tutorials. The student curated for 9 hours over 13 sessions.

clipping once every 1.64 minutes (Table 7.3). One-hundred percent of students navigated the zoomable canvas by panning and 99% of students used zooming. Students performed 2.07 pans and 1.43 zooms per minute.

Similarly, 97% of students used the control menu to perform operations requiring parameter adjustment. This is evidenced by the number of scale operations. The

most common element transform is positioning; the second most common is scale. The only operations performed by fewer than ninety percent of students were: rotate, layer, blend, and multi-select.

Some students learned to use the control menu in expert mode. Expert mode enables the user to fluidly select an operation and adjust its parameters in one gesture. In Semester III, 67 (23%) students used expert mode for at least 10 percent of their control menu operations. Forty-two students (14%) used expert mode for at least 25 percent. These numbers suggest their lack of particular expertise and minimal training, some students learned to use the control menu as experts.

8. HOLISTIC PRINCIPLES

Synthesizing our conceptual framing with the results of the field study, we develop holistic principles for expressive web curation, manifesting how medium, system, mind, and body become intertwined in experience. Expressive media and systems require interaction and information visualization techniques that address not only atomized sub-processes of expression, but the creative act as a whole.

Our principles of expressive web curation are: direct manipulation rich clipping, diverse and heterogeneous media, freeform medium of assemblage, multi-scale organization, sketching as annotation, and direct manipulation command selection and parameter adjustment. We elaborate each principle. We provide supporting evidence from student interviews, curation products, and interaction logs. We situate the principles amidst the web curation landscape.

8.1 Direct Manipulation Rich Clipping

Facilitate gathering clippings as elements of curation with automatically associated rich context.

As people copy, paste, and clip content from the Web, they tend to lose track of source documents [55]. While a few systems, such as Facebook, extract semantic information when a link is shared, many systems in our web curation landscape provide more minimal context: just the URL. In Prezi, clipped content becomes completely orphaned from its context, and this is typical of word processing, presentation, and graphic design tools. Capturing rich context during the gathering stage of curation, and integrating this context into the medium of the elements of curation enables subsequent support for re-finding and exploration.

Pinterest Pins use images and video as the media for elements of curation. Pins

typically provide limited context: the URL and title of the source page. If a source page registers itself with Pinterest, Pins may include additional metadata. The extreme popularity of Pinterest [11] demonstrates the efficacy of amalgamating visual and semantic forms in the media of elements of curation. Likewise, the value of image clippings integrated with rich metadata is demonstrated by the success of Polyvore. However, Polyvore limits users to curating content from pre-compiled collections, instead of from the whole Web.

IdeaMâché automatically captures the contexts of source documents, as the user gathers each clipping, via a web browser extension. Context is represented as rich metadata, using types. Clipping and context are joined to form a rich bookmark. Using rich bookmarks as the medium of elements curation supports user processes of appropriation.

Appropriation is the process through which people gather objects and make them their own, developing emergent uses [63]. The *Children's Peter Pan Inspired Room* (Figure 7.1) provides an example of appropriation through rich bookmarks. The student author gathered rich bookmarks from Ikea, specifically bedroom curtains and decorations. By using annotations and the placing these Ikea products in context of her assemblage, she appropriates the standard decor into wildlife and ambience from the forests of Never Neverland.

Students reported that they valued the automatically provided context of rich bookmarks, including the dynamic metadata that connected clippings to their sources. Students used the associated metadata of their rich bookmarks to explore and navigate to new content. Students were able to use the captured context for exploration and re-finding. Forty-seven percent of students used the dynamic metadata associated with rich bookmarks to re-find source pages.

S3: It's way easier to weblink stuff [than Prezi]. Just drag and drop.

S9: [I don't want to] create another document to keep track of those sources. . . . Whereas with this, it's all right here . . . You just click directly to the website . . . You can add metadata to it so you can have multiple things you can click on about it... Having all that information in one [place] is really convenient.

Q79: You have to just click-and-drag info instead of write it down. [It] takes you directly to link instead of having to find it later.

8.2 Diverse and Heterogeneous Media

Support freely gathering and assembling diverse and heterogenous media.

In addition to automatically provided context, systems should support users in curating any media they find significant, from any web source. Users benefit from being able to freely gather diverse forms of media. Rich media, including images and animation, promote cognition, learning, and re-finding. Human cognition processes information across senses and synthesizes meaning across them in parallel [3]. The episodic buffer enables combining visual and textual working memories [2], and thus supports synthesis across modalities. Thus, curation media that combine text, images, and video makes excellent use of cognitive resources.

Higher level cognition has been found to build on these structures of human memory. Combining images with descriptive texts promotes the formation of mental models, and so extend working memory capacity [18, 19]. Using imagery and animation in instructional media has been found to enhance cognition and learning [43]. Combining image and text in visual snippets helps searching and re-finding [60].

IdeaMâché supported students in gathering media from diverse sources, across the World Wide Web, and from their own devices. For the Imagine a Solution Curation

assignment in Semester III, students appropriated content from 3712 different web domains. Along with content clipped from the Web, 23% of students uploaded images directly from their local devices.

IdeaMâché supported students in gathering diverse media types. The medium and system supported students in gathering image, text, video and audio clippings. Thirty-two percent of curations from Semester III contain at least one video clipping. Interviewed students specifically commented how gathering videos adds expressive value.

S6: I was on YouTube and I accidentally grabbed that instead of something else. And it just dragged the video and the video popped up so I was, “Oh, that’s cool.”

S2: I played it and I [thought] “This is so beautiful! I know exactly what song I’m going to add to there, because, it’s just a love song that sums it all up.”

Like IdeaMâché, systems should support curation of diverse and heterogeneous elements to promote creative synthesis. People generate new ideas by combining diverse, rather than similar, elements [65]. The additional cognitive effort required for aligning diverse concepts and remote associates stimulates the cognitive restructuring [40] of ideation.

8.3 Freeform Medium of Assemblage

Enable freeform assembly of curation elements to form a meaningful whole.

As people engage in curation, they gather and assemble content to develop and express ideas. Complex and open-ended questions often require understanding information from multiple perspectives. Combining elements leads to comparison. When

elements are similar, the result is understanding, while combining dissimilar elements better stimulates creativity [65]. Freeform media of assemblage support the intentional articulation of relationships through operations such as spatial juxtaposition, blending, and sketch annotation. They thus stimulate conceptual combination and so provide a basis for creative cognitive processes in the authoring and interpretation of curations.

An assemblage is a work of art made by fastening together... The symbolic meaning of [constituent] objects, not originally intended as art materials, can be as important as their realistic aspects [56].

Web curation serves digital assemblage. Materials, in the form of image, text, and video clippings, are captured and placed together. In this combined form, each clipping exists with both its initial meaning and its new meaning, derived from its new context among the other clippings in the collection.

Seeing new relationships across an assemblage contributes to creative synthesis and emergence [33]. Meanwhile, extremely popular everyday social media, such as Facebook and Twitter, constrain expressive curation to linear feeds. The first-in first-out boards of other web curation tools, such as Pinterest, likewise function as linear media of assemblage. Going beyond the feed and the board by using a freeform medium of assemblage, information composition, supports flexible organization and expressive visual presentation.

Data support this principle of freeform media of assemblage. The interaction logs from semester III show that nearly all, 97%, of the students repositioned and scaled elements as they assembled their curations. Student curations, such as *Stages of Love* (Figure 1.1) and *Children's Peter Pan Inspired Room* (Figure 7.1) provide compelling visual evidence for how people can express themselves in a freeform medium of as-

semblage. Elements are combined. Interesting relationships are developed through expression.

Along these lines, in semi-structured interviews, students observed that IdeaMâché's nonlinear medium of assemblage was more flexible and helped them express and organize their ideas.

S7: I don't like using [Pinterest] because some of the constraints it has. ...I can't move my objects around. I get annoyed, you know, because it's rigid. ...I can't put them together in the way that I want to. ...Sometimes you just want your images to kind of line up, and... when I was using it you couldn't even change the order.

S9: I like how IdeaMâché ... [collects content] into one area. Whereas Pinterest, it like floats to the bottom, you know? When you start pinning stuff and then you have to scroll ... This is a lot more organized.

S5: I like that [IdeaMâché] left it up to you to be completely personalized with what you wanted to do. There [were no] guidelines of what you have to follow or a certain way you have to design the stuff.

8.4 Multi-scale Information Organization

Enable organizing and connecting visual and semantic representations of information across multiple levels of scale.

By *multi-scale organization*, we mean the placement of elements at different levels of scale to create nested connections and structures. Scale creates a dynamic gradient of detail in presentation. The use of multiple scales harnesses human spatial thinking in order to preserve the inherent richness and dynamic structures of information.

Multiple techniques have been developed to support presenting and navigating large datasets. Some techniques provide multiple simultaneous views of the infor-

mation, while others manipulate a single view. These techniques can be categorized by the views, manipulations, and transitions they support. Large information space navigation techniques include: overview+detail, zooming, focus+context, and cue-based [10].

Overview+detail interfaces provide two or more views of varying scales. Zoomable user interfaces (ZUIs) enable the user to manually control the scale of the view, using continuous changes in scale as a fundamental interaction technique [5]. Cockburn et al found that effective ZUIs typically use additional techniques, in combination with zooming [10].

The curation medium and system of IdeaMâché combines overview+detail and zooming techniques. The zoomable canvas and scale transforms afford freeform and multi-scale assemblage of curated elements and annotations. The creative process data (for Semester III) shows that students frequently manipulated the zoomable canvas using camera panning and zooming (Table 7.3). They made extensive use of element transforms, especially scaling and positioning, to articulate ideas and relationships through visual design.

The use of scale helps differentiate and separate elements into groups. These groups serve as chunks, helping make efficient use of human working memory [58]. A chunk integrates individual elements, forming a set, which can function as a single atomic unit in working memory, despite its complex makeup. Chunking thus works to scale the information that a human being can think about at one time.

In *Children's Peter Pan Inspired Room* (Figure 7.1), the author uses multiple levels of scale to organize the information. At the top level of scale, there is map of Never Neverland. Arranged around the map are groups of elements at a reduced scale, such as a group of pirate related elements to the right of the map. Within the pirate themed group scale is uses to create smaller groups, of sailing related

decorations and nautical maps to be used wall art.

Ability to scale the canvas space helped users assemble larger collections. The increase in Document Flexibility from semester I to III shows how zooming supports flexible thinking. We interpret the significant increase in Document Flexibility, but not Website Flexibility, to mean that zooming helped students curate more deeply in particular sites, but not to go back through search to traverse more broadly across sites.

8.5 Sketching as Annotation

Afford articulating relationships and expressing ideas with text and sketch annotation.

Annotation is, “the action of making notes,” to explain, comment or expound [49]. Annotations are notes, labels, and glyphs [61] made amidst prior content. As the size and complexity of a curation increases, so does the need for annotation, to support authors in ideation and to communicate. Curation media need to make annotation easy, flexible, and visually compelling to support users in creating meaning for themselves and others.

The assumed medium of annotation is text, and indeed textual annotation remains important and valuable. Yet, prior research finds the focus on text in prior discussions of human communication to be narrow [61]. We observe that in the digital era, with ubiquitous high resolution screens, the importance of visual communication grows.

Tversky observes the importance of diagrams as a form of visual communication [61]. Among their functions, she observes organizing space, mapping meanings to space, expressing center-periphery relationships, creating meaningful patterns, conception, and communication. Larkin and Simon show how diagrams can be easier to

understand than lists of relationships [36]. Benefits include using location to group information and making inferences easy to perceive. Diagrams predate written language as a form for permanent communication.

Glyphs are the simple figures that people sketch, such as points, lines, and arrows that draw from their context to articulate meaning [61]. Glyphs, through their simplicity, are abstractions that can encourage generalization and convey abstract concepts. She emphasizes the role of human interpretation in creating and understanding their meanings in context. We observe the importance of glyphs, as a means for explaining, commenting, and expounding, in sketching as medium of annotation.

In the prior Web curation landscape, annotations generally can be used only to label an entire curation or individual elements. There is no means to annotate across subsets of elements. Most tools only provide mechanisms such as titles, tags, and comments.

Prior sketch interfaces recognize actions and shapes. SILK was a system for designing interfaces, which recognized drawn shapes to form and act on interactive widgets [35]. Electronic Cocktail Napkin's sketch-based interface supported recording, organizing, and finding glyphs and sketches [20].

Instead of invoking machine recognition of sketching, IdeaMâché emphasizes expression. IdeaMâché supports creating rich text and sketch annotations. Text annotation editing includes expressive text formatting features such as font, size, color, and alignment. With the goal of reducing complexity, we provide a minimal set of sketching features to enable drawing simple glyphs. Sketching is implemented using the our control menu, facilitating access to brush size and color selection.

Students in Semester III created an average of 5.7 sketches and 12.4 text annotations per curation (Table 7.1). Sketch was used to define borders and boundaries between elements and, via arrows, to express flows. Sketched glyphs serve to artic-

ulate connections between elements and text annotations. In *Children's Peter Pan Inspired Room*, Figure 7.1), the author uses arrows to associate subsets of elements with particular thematic concepts. The glyph annotations are complemented by text annotations that label groups.

Between Semester I and Semester III, the number of image and text clippings did not significantly increase, but the use of text annotations did. We hypothesize that sketching and text annotation are complementary modes of expression.

To investigate, we applied a Pearson's product-moment correlation for Fluency between Sketch Annotations and other media that users curated. All correlations are statistically significant (Text Annotations $p < 1.0 \times 10^{-15}$, $r = 0.54$; Text Clippings $p < 0.013$, $r = 0.14$; Image Clippings $p < 0.00001$ $r = 0.26$). The correlation between Sketch Annotation Fluency and Text Annotation Fluency is especially strong. This is buttressed by the significant increase in Text Annotation Fluency between Semesters I and III. We find that combining simple sketching and text editing capabilities increases students' engagement in writing, and curation, while opening new avenues of expression.

This human-centered approach leaves recognition to authors and readers, in contexts of curation. Sketching is emphasized as a direct form of expression.

8.6 Direct Manipulation Command Selection and Parameter Adjustment

Use direct manipulation command selection and parameter adjustment to engage novice and expert users in expression.

The organization and design of a curation evolves continuously, as elements are added and removed. Interfaces that support fluid manipulation of content reduce effort required for organizing ideas. Decreasing the required cognitive and neuromuscular effort gives users more cognitive resources to invest in ideation. The successful

use of our control menu by the DPCE students shows that direct manipulation command selection and parameter adjustment techniques can support users with varying levels of expertise.

Marking and control menu interaction techniques optimize interaction design, e.g. for command selection and parameter adjustment, by utilizing visual, cognitive, and neuromuscular factors, and reducing effort. The marking menu improves human performance on command selection with radial layout [34]. The control menu is a type of marking menu, in which selection, activation, and parameter adjustment are performed in a single fluid gesture [52]. While they have been previously used by experts (e.g., Maya) and in laboratory studies, the present research integrates a radial and control menu, while supporting novice and expert use.

IdeaMâché was deployed in an introductory undergraduate course with no prerequisites. The class is taken by students from diverse majors and backgrounds. We know from their help desk queries that most students are not expert users.

IdeaMâché's control menu integrates support for novice and expert users. The menu enables users to arrange elements in short continuous gestures. Expert mode enables users to quickly select, adjust, and execute operations in a single press, drag, and release of the mouse. Novice mode allows users to select and execute operations through a series of mouse clicks. Novice mode also supports discovery of affordances and mappings by displaying labels for all menu options. This supports users unfamiliar with marking gestures.

Process data shows that novice student users are capable of manipulating elements through our control menu. Ninety-seven percent of students used the control menu to perform scale adjustments and over half of the students performed rotations, blends, and multi-selects. To perform any of these, the user selects the operation, then continuously drags to adjust its parameters. Adjustments work the same way

in both novice and expert mode. The extensive use of element transforms shows that novices can use a control menu.

Students reported that the structures and affordances of our expressive web curation medium were more fluidly editable, distinguishing it from familiar tools. Interviewees reported that the IdeaMâché control menu was easy to use, but was unfamiliar and so had to be learned.

S6: For me it was [easy to use] because I kind of have more of a computer background. . . I actually went and showed one of my group members different ways to use the control button and then she could use it after that.

S2: I didn't have trouble using [the control menu], but it took me a while to figure it out.

9. DISCUSSION

There are many contexts of curation. Curation occurs whenever an individual gathers and assembles information with the intent of exhibition. One way people engage in curation by filtering and selecting content in everyday social networks. Reddit, Twitter, and Facebook are social media of curation.

In these media, elements of curation are increasingly heterogeneous, supporting links to any Web content. Facebook provides rich snippets of text and image previews from links. Twitter and Facebook recently provide in-line views of images and video. However, these systems share a limited medium of assemblage: linear feeds and grid-based boards. Holistic principles of expressive web curation show how to take the user experience beyond.

“Liking” on Facebook and “upvoting” on Reddit are examples of curation. Curations result from individual or collaborative effort. As users in social networks choose to include or promote specific content, they become dynamically engaged in curation. We advocate making the elements and assemblages of social curation more freeform and richer to better support everyday acts of ideation.

Increasing expressive capabilities increases the potential for meaningful experience and creativity. Prior scholarly curation tools lack a freeform medium of assemblage. Researchers engage in non-linear thinking as they collect related articles and content, looking for relationships and synthesizing concepts. Scholarly web curation systems, such as Zotero or Mendeley, only support textual elements of curation. Instead, scholarly and educational tools should also support visual cognition with images and videos. As Marchionini and Crane observed, “integration of text and graphic[al] materials expand[s] the scope of course assignments and discussions

...students in literature courses reported using the graphic materials ... to provide context for their textual interpretations” [41].

Everyday social media of curation’s use of feeds similarly restricts expressing relationships across posts. Collections of individual posts and Tweets are assembled primarily as chronological lists. While feeds are useful, more freeform media of assemblage would provide people with more value from their posts, by better supporting developing relationships, synthesis, and emergence.

Board-based media of curation (e.g. Pinterest) only support image and video elements. The lack of support for text does fails to concurrently utilize the visuospatial and phonological cognitive subsystems [3]. The board medium of assemblage does not afford expressing connections and associations among elements.

In addition web curation media and systems, we call on publishers and tool builders to serve users by facilitating expressive web curation. Digital libraries and archives can take steps to better support expressive curation. For example, images from scholarly articles should be directly available via HTML. Libraries can regularly author expressive curations of timely, significant content from their collections to create digital display cases. These collections can be designed to target specific user groups based on their interests and tasks.

Likewise, PDF readers can make their documents more valuable by facilitating curation. They should make images and text directly selectable and enable the drag and drop of selections using standard data transfer specifications.

10. CONCLUSION

We developed holistic principles for expressive web curation. We explained our holistic approach to creative expression and, by extension, web curation. We surveyed the current web curation landscape. We presented a system, IdeaMâché, which manifests our developed principles.

In a field study spanning three semesters, students produced web curations exhibiting complex ideas. They gathered, assembled, composed, designed, annotated, and exhibited found information to express relationships and generate ideas. Many were proud of their work. Fifty-eight of the 132 students from semester I reported that they showed their curation to someone other than the instructor. They used expressive web curation to create personally meaningful web curations, such as whether or not to get a new tattoo and how to “forget the jerk existed”.

Media of curation *are* changing the world. People expressive themselves through communication in popular everyday social media. Prior popular social media are highly effective and yet, with regard to their form and structure, we identify their linearity as transitional. The linear forms of these prior media of curation are a vestige of century-old forms such as the book, the newspaper, and the magazine. Holistic principals of expressive web curation can serve as a basis for richer forms of expression. For example, while Facebook’s video summaries of your year can linearly connect your personally meaningful epiphanies, they do not support re-finding. They do not support intricate forms of associationality and expressing complex relationships. In short, they may be good for nostalgia, but not for curation and ideation.

The expanding influence of digital media is coupled with the human desire to engage in ideation through curation. The media of web curation directly affect

expression and creativity. Creativity is inherently a demanding enterprise. The easier gathering, assembling, exploring, re-finding, and reflecting become, the more people will engage in meaningful web curation.

Engagement in curation has the potential to unlock the fantastic, growing legacy of digital information. Flexible media of assemblage provide degrees of freedom for emergent juxtaposition, synthesis, and ideation. Expressive web curation can serve as fuel for human imagination, feeding personal well-being and invention that transforms society.

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