AN ANALYSIS OF INFORMAL, MARINE-ORIENTED PROGRAMS FOR UNDERSERVED STUDENTS OF THE TEXAS GULF COAST: STRATEGIES FOR IMPROVING EDUCATIONAL STEM OPPORTUNITIES

A Record of Study

by

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ABSTRACT

Research shows that a high percentage of science organizations in the United States offer programs specifically designed for K-12 students and teachers. These programs include, but are not limited to supplementary classroom experiences and science learning opportunities in the form of afterschool, summer, and weekend programs for underserved populations. Successful formal-informal collaborations allow participants to explore and understand a vast range of science topics. Successful community partnerships amongst informal educators themselves allow for improved resources for formal educators. In this study, I examined the informal marine education programs in the Texas Gulf Coast region and explored the practices they offer in STEM fields. I used a convergent parallel mixed methods design that involved both qualitative and quantitative data collection phases to determine the level and the value of the STEM opportunities provided by the informal marine education programs. I interviewed five participants from five informal marine education programs in the Texas Gulf Coast region and asked them their opinions and views of STEM education quality and accessibility of their informal marine education program. Twenty two participants completed a survey designed to explore participants' perceptions about the quality of STEM education in informal marine education programs serving the Texas Gulf Coast. Findings indicate that while there is success in providing meaningful STEM opportunities, barriers exist in making programs financially accessible.

DEDICATION

For Virginia. The sweetest, sassiest, smartest, bravest, fastest, toughest, greatest girl that ever was.

CONTRIBUTORS AND FUNDING SOURCES

Part 1, Faculty Committee Recognition

This work was supervised by a dissertation committee consisting of Chair Bugrahan Yalvac, Co-Chair Mary Margaret Capraro, and Julie Singleton of the Department of Teaching, Learning, and Culture at Texas A&M University and Beverly Irby of the Department of Educational Administration and Human Resource Development at Texas A&M University.

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All work for the record of study was completed by the student. Advisors Bugrahan Yalvac and Mary Margaret Capraro of the Department of Teaching, Learning, and Culture established emphasis on development of educational leadership knowledge and skills in curriculum and instruction.

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CHAPTER I

INTRODUCTION

Students can learn about science in a variety of formal and informal environments. Crane, Nicholson, Chen, and Bitgood (1994), explained that learning in informal science includes learning that occurs outside the formal school setting which is not necessarily designed for formal school use or formal school curriculum. Science learning occurs over time through a multitude of life experiences, including experiences inside and outside of school (Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003). Experiences children have in situations in and out of school influence the ways their attitudes towards, and understanding of science develop. This comprehensive view of learning acknowledges that much of what individuals come to know and understand, including science concepts, is derived from life experiences within a diversity of contexts (Dierking et al., 2003).

The ways in which informal science emerges to public audiences are various and abundant. Throughout the United States, science-based institutions, such as zoos, aquariums, universities, and non-profit programs have collaborated with schools to offer students and teachers opportunities to expand understanding of science through meaningful experiences (Bevan, Dillon, Hein, Macdonald, Michalchik, Miller, Root, Rudder, Xanthoudaki, & Yoon, 2010). A study by Phillips, Finkelstein, and Wever-Frerichs (2007) reported that more than 70% of informal science program providers in the United States have activities especially designed for K-12 students and teachers.

Other researchers are noticing that informal science education programs are committed to engaging students and educators from underserved communities in order to expand program accessibility (Bevan et al., 2010).

Study Purpose

Informal education programs serve specific geographic areas of formal education. They have the potential to better serve all stakeholders involved in the process of enhancing formal education with informal experiences, especially in historically underserved populations in Science, Technology, Engineering, and Mathematics (STEM). Formal-informal collaborations in education exist to expose students to a wide variety of educational experiences (Bevan et al., 2010). The purpose of this study is to analyze the STEM opportunities provided by informal marine education programs from a specific geographic area.

Study Rationale

Ideal Situation

In an ideal situation, informal marine education programs serving the Texas Gulf Coast recognize the value of providing meaningful out-of-school STEM opportunities for underserved students. Promoting equity and diversity in STEM learning requires (a) expanding access to new opportunities for learning; (b) providing opportunities for continuing and deepening learning; and (c) designing learning opportunities that deeply connect with and reflect the lived experiences of young people. Out of this recognition of value, informal marine educators serving the Texas Gulf Coast recognize the potential benefits of informal STEM learning and analyze their programs accordingly to assure meaningful STEM experiences are included in their program curriculum/activities. Informal educators serving the Texas Gulf Coast work together as community partners to identify strengths and weaknesses in informal STEM programming, and in doing so play an empowering role in efforts to enhance formal education with experiences in informal education.

Real Situation

In the real situation, there are multiple informal marine education programs serving the Texas Gulf Coast and they offer different STEM opportunities and resources for teachers, students, and the general public. However, there is no research available to support the quality of STEM activities within their programming, whether or not these STEM opportunities are valuable or how they relate to formal education and community partnerships. Informal organizations that have many valuable and potentially beneficial science-related programming are not being used to their fullest potential because the informal marine education programs along the Texas Gulf Coast are not being thoughtfully analyzed and are fragmented where they should be united in working toward common goals.

CHAPTER II

REVIEW OF THE LITERATURE

Learning

Researchers do not agree on one specific definition of learning (Shuell, 1986). Many theories have been used to explain the processes involved in learning. Theories include behaviorist, social learning, cognitive, humanistic, and experiential. According to the experiential model of learning, learning is "the process whereby knowledge is created through the transformation of experiences. Knowledge results from the combination of grasping experiences and transforming them" (Kolb, 1984, p.41).

Dewey (1938) originally described the benefits of experiential education, explaining a meaningful relationship between the processes of life experiences and education. Humanizing education through real-life activities is essential in education. A child's capacity to grow and their motivation to learn occur because they possess exploratory inclinations and impulses (Schiro, 2013). Implications of experiential learning theory in formal education involve protocol offering students hands-on and reflective learning experiences (Haynes, 2007). Wurdinger and Carlson (2010) stated that in experiential learning students make decisions to be involved in their learning experiences. Students actively participate in their own learning and develop a meaningful role in their learning process. Students are not left alone to teach themselves. The instructor acts as a facilitator during the learning process (Wurdinger & Carlson, 2010).

Informal Learning

The term informal learning refers to separate yet similar areas of study. Researchers and practitioners may refer to informal learning as learning that occurs in organized, non-school settings such as museums. Others may use the term informal learning to focus on learning with family, on playgrounds, or in other situations where an organized educational agenda is not maintained (Bransford, Derry, Berliner, Hammerness, & Beckett, 2005). This study focuses on informal learning in organized, non-school settings.

Research on informal science learning is reflective of the many theoretical perspectives on learning. The three theoretical perspectives of learning that have been significant in understanding learning and educational processes are: *behaviorist*, *cognitive,* and *sociocultural* (National Research Council, 2009). Behaviorism describes knowledge structured growth involving responses to stimulus as elements of skills (Thorndike, 1931). Cognitive theories increase understanding of development and application of knowledge in relation to life experiences. Sociocultural theory acknowledges cognitive perspectives while emphasizing cultural origins of human development and examines individual development in cultural contexts (Rogoff, 2003). Behaviorist, cognitive, and sociocultural perspectives have influenced design of informal science learning environments (National Research Council, 2009).

Experiential learning is an integrative theory that is based on a diverse set of theoretical traditions, including behaviorist, cognitive, and social theories (Kolb, 1984). Informal science experiences are described as learner-motivated and contextually relevant (Falk & Dierking, 2000). Informal science learning experiences offer many participant benefits including enhanced inquiry, enjoyment, and the idea that science learning can be personally meaningful. Participants in informal science learning experiences are diverse and include learners of all ages and backgrounds (National Research Council, 2009). Informal science learning environments and experiences may lead to important contributions to society. Serious scientific concerns exist in today's world (e.g., global warming and stem cell research). Many concerned citizens and scientific organizations have argued that society will have to learn to rely on and utilize all available resources to improve science learning and literacy (National Research Council, 2009).

According to the National Research Council (2009), informal STEM programs typically incorporate six learning strategies shown to support effective learning:

- Build on learner interests
- Hands-on
- Inquiry-based
- Connect STEM to everyday life and experiences
- Knowledgeable facilitators
- Collaborative environment

Informal educators are playing an increasingly critical role in designing and implementing educational experiences that fully engage students. Recent concerns about the ability of STEM-related fields to attract and retain students have created a demand for highly engaging programs for youth (Habash & Suurtamm, 2010). Informal science programs for youth (i.e., field trips and summer camps) have proven to be effective in assessing and promoting student interest in science as a potential career. Informal science programs have also proven to help students develop analytical skills and help students prepare for college (Habash & Suurtamm, 2010). Hayden, Ouyang, Scinski, Olszewski, & Bielefeldt (2011) described iQUEST (investigation for Quality Understanding and Engagement for Students and Teachers) as a project designed of six elements to promote student interest and engagement in STEM. One of the six elements in the iQUEST project included summer camp experiences. Hayden et al. (2011) reported that the iQUEST student summer camp results showed that underserved students exhibited increased interest and attitudes toward STEM. The iQUEST summer camp (offered in 2010) selected underserved populations of middle school students and provided them the opportunity to attend a one-week summer camp experience on a university campus (Hayden et al., 2011). Summer camp impact on student attitudes toward STEM was assessed by surveys, one administered at the beginning and one administered at the end of each iQUEST camp session. The surveys measured student interest in science and careers in STEM and student perceptions about their competence in STEM. Cumulative scores for all participants increased significantly in the surveys administered at the end of the iQUEST summer camp experience (Hayden et al., 2011).

Informal programs are highly beneficial to minority and at-risk children. Welsh, Russell, Williams, Reisner, & White (2002) evaluated a New York City program for undeserved students. They found that racial/ethnic minorities, low-performing, and low-income students benefitted academically. African American students demonstrated gains in math that increased each year they participated in the program compared to similar students who did not participate. McQueen, Wright, and Fox (2012) stated that experiential learning activities, such as academic summer camps, have proven to be effective for changing student perceptions in traditionally challenging subjects such as science. They conducted a three year research study with more than 1,300 students and teachers. Study participants attended a one-day genomics field trip. Participants explored science concepts associated with DNA, DNA sequencing, genomes, and personal genomics. In an effort to connect learning objectives to school curricula, the teachers and their classes willingly provided comments and suggestions to assist connecting field trip objectives and content to curricula. All participating students responded positively to this field trip experience in survey questions. Student comments included statements such as, ‘‘this program allows us to see how useful science contributes to our everyday life’’ (McQueen, Wright, & Fox, 2012, p. 5). Unfortunately, in many school districts, out-of-school programs and field trips during the school year are eliminated due to financial restraints. Transportation, lodging (if necessary), equipment, materials, and supplies can be extremely cost prohibitive (Switzer, 1995).

Equity and Out-of-School STEM Programs

The majority of reform efforts addressing the goals of STEM education have focused on formal education; however K-12 students only spend 20% of their time in formal school settings. The other 80% is spent in informal environments, including after school and summer programs (Stevens, Branford, & Stevens, 2005). Meaningful experiences with STEM expose young people to critical and collaborative thinking.

Meaningful experiences in formal education are essential, but insufficient for young people to get involved with science and to be prepared with the skills necessary to pursue STEM fields beyond high school, especially in underserved populations (Lyon, 2013). Public schools in the United States have been historically funded through property taxes. Because families tend to sort themselves into homogenous groups of like median incomes, properties of lower value are owned and occupied by families of lower income (Card & Payne, 2002). These tendencies create disparities in student funding between districts, the wealthiest districts spending nearly three times as much per student as the lowest socioeconomic districts (Condron & Roscigno, 2003).

Lyon (2013) suggested that without an organized plan for how underserved students will get involved and stay involved with STEM, the status quo will remain the same:

- Underserved students will not fully explore the world around them.
- Student achievement in STEM in formal education will remain at low levels.
- Diverse learner populations will remain underrepresented in informal STEM programming.
- STEM education efforts will lack systemic impact.
- Local workforces will not have the diverse selection of applicants they need (Lyon, 2013).

According to The National Research Council (2011), an achievement gap exists between Caucasian and minority students in K-12 STEM subjects. This concern is documented in research reports such as The Nation's Report Card. These reports reaffirm that family differences and school context have an important impact on student achievement in formal and informal learning environments. Research suggests that widening achievement gaps as students in K-12 progress through school are a result of differential learning growth, inequality in access to out of school programming, and learning loss during the summer (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996). Students may lose approximately two months of grade associated skills in math and science in the summer. These findings have been associated with greater ability among higher-income parents to provide their children with STEM stimulating materials and activities during the summer (National Research Council, 2011).

Kena et al. (2014) reported that 21% of K-12 children in the United States were living in poverty. There are challenges to providing students in underserved communities with accessibility to informal STEM learning opportunities. Most challenges involve issues of funding. Many informal STEM programs charge some type of fee or tuition (Dierking, 2007). Alvarez, Edwards, and Harris (2010) suggested an increase in searches for activities that allow underserved students to overcome issues such as low educational achievement and lack of exposure to STEM opportunities and STEM career choices. Yerrick and Beatty-Adler (2011) conducted a research study which included over 300 sixth graders. Most of the study participants were considered underserved students. The study participants attended activities at an aquarium in an urban area. The researchers found teacher quality and beliefs about informal education at the middle school to be at a lower level than middle schools in higher family income areas. The researchers believed lower levels of teacher quality and attitude toward informal education impacted teacher perception and program participation. Consequently, low level of teacher participation adversely affected the ability to provide meaningful activities to underserved students.

Yerrick and Beatty-Adler (2011) argued that:

> Even when students are given equal financial support for trips, excursions, and similar opportunities, it should not be assumed that all students have been treated equitably. There are many ways that science can be represented and there is considerable debate among researchers regarding the accuracy of the representations of the knowledge or of the activities of scientific experts. (p. 231)

Promoting equity in STEM requires attention to providing young people access to powerful settings for learning; supporting them to make connections and have opportunities across settings, and attending to how access to disciplinary practices is shaped by what goes on in particular learning settings (Hand, Penuel, & Gutiérrez, 2012). STEM learning experiences for underserved students are only possible when all stakeholders recognize and understand the importance of accessibility in STEM education. Ongoing support and reassurance is essential for diverse learners to overcome accessibility barriers to STEM opportunities (Kaser, 2010).

Minority Student Population in the United States

According to the Diversity Pipeline Alliance (2002), minorities accounted for approximately 30% of the population of the United States. According to public data, it is estimated that by 2050 minorities will represent approximately 50% of the total U.S.

population. This means people historically considered to be racially diverse may no longer be a statistical minority (Diversity Pipeline Alliance, 2002). According to Maxwell (2014), the current minority student population in American public schools is projected to exceed the majority. Maxwell (2014) stated that projections by the National Center for Education Statistics showed current minority student populations rising above 50%. This is due to a population decline of non-Hispanic students and a steady rise in Hispanic student enrollment. The shift toward a new majority has already occurred in the West and South regions of the United States. As of the 2011-2012 school year, data analyses have provided insight indicating significant minority student increase in approximately 18.5% of public schools (Maxwell, 2014). Enrollment transformation presents challenges for educators, including increased poverty levels amongst students, an increase in the need for English-language instruction, and more students with different life and cultural experiences than their non-Hispanic educators (Maxwell, 2014).

A reality in education is that underserved student populations in the United States lack accessibility to higher education (Ntiri, 2001). Obstacles to equality in education include financial difficulty; lack of family support, low standardized test scores, and in many cases an absence of positive role models and community support (Ntiri, 2001). Efforts in recruiting should begin early by reaching out to younger students (Opp, 2001). Effective programs designed to inflate the number of students enrolling in higher education are comprised primarily of programs that work directly with schools to increase educational opportunities (Ntiri, 2001). In order to increase minority enrollment in higher education and within professions, it is essential to support meaningful educational opportunities for K-12 minority students (Haycock, 2001).

Lack of Informal Learning Connections

Wenger (1998) explained that informal learning is associated with educational research about authentic experiences in education that occur in a social context. Research in education has shown that meaningful learning occurs in authentic practices using inquiry-based approaches and by making meaning through action (Wenger, 1998). Often only a select group of students are provided with opportunities to participate in informal education activities. The students who are able to participate in informal activities are the only students who receive benefits from such extracurricular activities (Venville, Rennie, & Wallace, 2005). Underserved students may only live a short distance from a beach, ocean, museum, or wetland. However; they may lack accessibility to meaningful science activities at such locations because of financial limitations or other challenges which prohibit students from utilizing resources of their geographic region (Yerrick & Beatty-Adler, 2011). By incorporating informal activities relevant with classroom learning, meaningful connections can be made while impacting a more diverse demographic of students. Integrating informal learning with formal learning allows increased student participation and provides a platform for hands-on learning activities (Venville et al., 2005).

Schools are looking to the informal community for ideas about how to teach science, design solutions to problem-based challenges, and meet the goals reflected in the Next Generation Science Standards (National Research Council, 2012). Teachers see informal opportunities as ways to introduce and reinforce inquiry, project-based learning, and thoughtful discussions (Honey & Kanter, 2013). Educational leaders see the potential to engage underserved groups in STEM-related activities to help develop a more diverse workforce (Honey & Kanter, 2013).

Increasing Diversity in the Ocean Sciences

In 1990, the American Society of Limnology and Oceanography (ASLO) engaged in a pioneering effort to increase member diversity and participation in the aquatic/marine sciences (Cuker, 2001). The National Science Foundation (NSF) collects data on higher education degrees earned in the sciences. According to Cuker (2007), their classification system made it difficult to gather statistics for aquatic/marine sciences; however they included a category for ocean sciences. As of 2004 minority students accounted for nearly 30% of the undergraduate degrees in the sciences, but only 10% of the ocean science undergraduate and graduate degrees. This was lower than three percent for doctoral degrees. Cuker (2007) stated that these numbers indicated more minority sought ocean science careers in 2004 than in 1990, when ASLO began its diversity efforts. However, in bringing substantial diversity to the aquatic sciences, there was much work needed before reaching that goal. Minority students interested in STEM careers regularly choose health-science career paths. This is a suitable career path for some; however many minority students have not been introduced to other possibilities in STEM fields, including the marine sciences (Bingham, Sulkin, Strom, & Muller-Parker, 2003). Participants and researchers at past NSF conferences agreed that the lack of diversity in the marine sciences is an urgent topic that should be addressed (Seitz, 1992).

Czujko and Henley (2003) also reported that the geosciences continued to trail significantly behind other sciences in recruitment and in maintaining student diversity. The geosciences ranked lowest in diversity in comparison with other STEM disciplines (Velasco, 2010). Geosciences covers a broad range of topics such as soil, minerals, climate change, water sources including lakes, rivers, oceans, fossils, volcanoes and more. The NSF refers to its geosciences division as GEO and categorizes GEO as Atmospheric, Earth, Ocean, and Polar sciences.

According to NSF Advisory Committee for Geoscience (2014), their latest strategic planning effort, *Dynamic Earth: GEO Imperatives and Frontiers 2015–2020*, builds upon previous strategic planning efforts to fulfill GEO's mission to support research in the atmospheric, earth, geospace, ocean, and polar sciences. The document is organized around four thematic areas: (1) Research, (2) Community Resources & Infrastructure, (3) Data and Cyberinfrastructure and (4) Education & Diversity (NSF Advisory Committee for Geosciences, 2014). Each thematic area has supporting imperatives. NSF Advisory Committee for Geoscience (2014) stated that future geoscientists, such as hydrologists, geologists, oceanographers, and space scientists are vital to ensuring that reliable science guides our nation's conservation, management, and security strategies to confront global challenges. GEO has a strong interest in promoting participation and awareness of all the science it supports, as well as supporting and training the STEM workforce. Imperatives noted by GEO under the thematic area Education & Diversity include broadening the participation of underserved groups and promoting the use of community resources for both research and educational purposes (NSF Advisory Committee for Geosciences, 2014).

Velasco (2010) stated “two key populations must be considered as the United States looks to boost the future geosciences workforce and optimize productivity: the nation’s youth and its growing underrepresented community” (p. 289). Velasco (2010) also explained that:

> Key components for continued success at increasing diversity in the geosciences include the following: research experiences at high-school levels for underrepresented students, collaborative partnerships between academic institutions and underrepresented communities to enhance geosciences education, underrepresented student mentoring, incentives in the workforce to hire from underrepresented communities, and financial assistance. (p. 289)

CHAPTER III

RESEARCH METHOD

Study Design

This study is based on comprehensive data collection from each informal marine education program willing to participate, including mixed methods designs that directly address the primary research question and sub questions. Qualitative data are collected in the form of interviews and survey information and quantitative data are collected in the form of surveys. Understanding quantitative and qualitative strengths and weaknesses in research allows the researcher to combine strategies. Johnson and Turner (2003) described such methods of combining as the fundamental principle of mixed methods designs. When following this principle, researchers should collect sufficient applicable data using different methods in which the resulting combination is likely complementary strengths and weaknesses that do not overlap (Brewer & Hunter, 1989). The researcher's main roles in the process of implementing a solution to the problem consist of data collector, data analyst, and catalyst, as explained by Himmelman (2002) in which an organization or individual within an organization often acts as a facilitator on significant issues that may result in further action. The organization or individual may then use the role of facilitator to initiate discussion including future strategies.

The design of this study is mixed methods, specifically the convergent parallel design provided by Creswell and Clark (2011). The convergent parallel design will allow the researcher to develop a more comprehensive understanding of the research problem by collecting different but complementary data. Mixed methods design is chosen for the purpose of being complementary as described by Greene, Caracelli, and Graham (1989), in which the researcher seeks further elaboration and clarification of the results.

Research Questions

The primary research question is: What are the roles and characteristics of informal marine education programs in engaging underserved students of the Texas Gulf Coast in out-of-school STEM activities? This study addresses the issues facing underserved students in entering STEM pipelines through informal programming and community partnerships. The sub-questions that help address the main research question are:

1. What are the informal marine education programs doing to recognize equity and diversity in STEM education and expand access to STEM opportunities?
2. What are the characteristics of the STEM education practices operationalized by the informal marine education programs serving the Texas Gulf Coast?
3. What are the staff members' (i.e. program directors, assistant directors, coordinators, instructors, volunteers) perceptions of the quality of STEM instruction and engagement in current informal marine education activities?

Participants

The participants of this study were informal marine education staff members who have provided STEM learning opportunities along the Texas Gulf Coast. These participants have had diverse missions, but all offered informal marine-oriented programs and/or resources to students and educators from the formal K-12 sector. The participants included paid staff and volunteers from university organizations, non-profit groups, and science centers. I used convenience sampling and purposive sampling in choosing my study participants. Creswell (2008) described convenience sampling as when the researcher selects participants because they are in close proximity and available and willing to participate in the study.

Research Instruments

I designed a semi-structured interview protocol to explore the marine education staff members' perceptions about the quality of STEM instruction in informal marine education programs serving the Texas Gulf Coast (see Appendix B). An interview protocol consists of more than interview questions; it also guides the procedure of interviewing and includes a script of what the interviewer will say prior to the interview, prompts the interviewer to collect consent forms, script for what will be said at the conclusion of the interview, and reminds the interviewer of the information to collect (Jacob & Furgerson, 2012).

I used a modified STEM program assessment survey, originally developed by the foundation of The Power of Discovery: STEM^2, a partnership effort between the California Afterschool Network and the California STEM Learning Network (California After School Network, 2014). The purposes of this assessment survey were for me to gather informal STEM program data and to identify needs and characteristics of informal STEM programs. I used the survey to identify areas of support required to design and implement meaningful informal STEM programming (California After School Network, 2014). I also created Likert-style questionnaire items. Responses were measured on a 5-point Likert scale ranging from “Strongly Disagree” (1) to “Strongly Agree” (5). The Likert scale was designed to evaluate participants’ beliefs or confidence level in 12 items such as the quality of STEM activities offered by their programs, program ability to inspire student interest in STEM, program support of diversity in education, and program accessibility to underserved students. In order to assess the programs’ STEM-related quality and accessibility, the assessment survey was completed by 22 stakeholders at all levels of employment within each informal program.

Surveys can provide insight to research patterns of interest; however interview data often provide more detailed understanding on participant perceptions (Kendall, 2008). I used an interview protocol as an instrument to ensure all important issues were included in the conversations. The interview protocol was semi-structured. Semi-structured interviews utilize open-ended questions based on the researcher’s primary focus and are developed before data collection (DiCicco-Bloom & Crabtree, 2006). I created an interview protocol that allowed me to collect interview data about participants’ views and opinions about the quality of STEM education in informal marine education programs serving the Texas Gulf Coast.

Study Context

According to the American Fact Finder Survey (2007-2011), 16.4% of families in the area, located along the Texas Gulf Coast, had an income at or below the poverty level. Looking at the totals for all people in the area, family incomes were below poverty at 22.6% - with children under five having the highest rate in poverty at 39%. Of the

21,111 households identified in the American Community Survey, 12,990 (61%) made less than the 80% area median family income (AMFI).

According to public data, the formal K-12 education sector serving the area consists of an Independent School District (ISD). The district has a student enrollment of approximately 6,800 and includes two high schools, five middle schools, and six elementary schools. Student demographics are diverse with 47% being Hispanic, 28% Caucasian, and 25% African Americans. The district follows a school of choice model. This model allows freedom in choice of school based on curriculum, not geographic location. The ISD is not divided into zones, which allows for increased opportunities for personalized learning. Their decision not to include zones has attracted increased levels of interest and enrollment. District elementary programs are theme-focused, such as coastal studies, international studies, college readiness and balanced literacy, and STEM.

The area and its educators and students are still recovering from the effects of a major hurricane. During the 2008-2009 school years, over 50% of students were considered homeless, having been displaced. In 2010, 25% of students were still considered homeless living in temporary or transitional housing. The area has a school dropout rate of 22.3%. College readiness of graduates is disappointing with only 44% being college ready. A significant gap of 30% exists between Caucasian and minority students. Another gap exists with SAT/ACT scores, 45.5% of Caucasian students score at or above criterion while only 6.1% of African American students and 18.9% of Hispanic students meet or exceed the criterion. Standardized test results continue to show these same gaps for minority students. In reading/ELA the gap shows the minority students both scoring 12% lower than the Caucasian students. The gap in mathematics shows Hispanic students at 14% below Caucasian students, while the African American students are 27% lower. The gap in science is higher with Hispanics at 23% lower than Caucasian students and African American students at 30% lower. The ISD English Language Learners comprise 15% of its population, indicating this affects the Hispanic performance statistics.

The informal marine education community serving the area comprises informal science educators. The informal science educators represent non-profits, universities, zoos and aquariums, state parks, and nature centers. The informal marine education community also includes members from formal education, including classroom teachers, school administrators, education service centers, and higher education. It is a learning community that represents the area's regional and cultural diversity as well as the area's unique coastal atmosphere and maritime heritage. The informal marine education community is aware and supportive of the significant role informal institutions play in supporting a variety of learning opportunities. The informal marine education community serving the area offers a variety of STEM resources within local schools (in addition to their fee-based programs open to the public). Informal marine education programs in existence along the Texas Gulf Coast, particularly in the Galveston Bay region, offer programming for underserved students and are designed to increase interest in STEM. Such programming exists outside of school settings through the help of grant funding and in-kind donations from the programs themselves.

The interview protocol and questions have been approved by Texas A&M University's IRB (IRB2014-0539D), (see Appendix A). Pre-interviews with stakeholders took place during spring semester 2015. Completed pre-interviews were conducted on the campus of Texas A&M University at Galveston in the office of Educational Outreach. The program assessment survey was added and approved as an amendment to existing IRB2014-0539D (see Appendix A). Stakeholders were contacted via e-mail for completion of the survey.

Data Collection and Management

Ibert, Baumard, Donada, and Xuereb (2001) stated that, "Data collection is crucial to all research. Through this process, researchers accumulate empirical material on which to base their research" (p. 172). Data collection techniques in this study included mixed methods approaches. The researcher intended on using interviews and program assessment surveys. Interviewing is a technique used in qualitative approaches aimed at collecting data that reflects the thoughts of individual interviewees (Ibert et al., 2001).

Ibert et al. (2001) indicated that an effective and developed method of collecting primary data for quantitative research is the questionnaire. Using an assessment survey or questionnaire enables the researcher to directly question the participants. Assessment surveys are tools for collecting data in quantitative research, allowing the researcher to establish statistical relationships or numerical comparisons (Ibert et al., 2001).

I maintained paper files such as interview notes as well as an electronic database. All files were properly stored and maintained in the Department of Educational Outreach at Texas A&M University at Galveston. Interviews were conducted in an office setting at Texas A&M University at Galveston with ‘director level or higher’ staff members from each of the five informal marine education programs. Each interview took around 25 minutes. I recorded conversations on a digital voice recorder. I moved the recordings to a desktop computer and backed them up on an external hard drive. I stored and organized collected interview data using NVivo qualitative software.

I contacted each of the five informal marine education programs, explained my study, and obtained permission to distribute the survey to their staff involved in educational programming. A purposive sample of five ‘director level or higher’ staff members (one from each of the five programs) and 22 informal marine educators (representing all five programs) provided program characteristics, attributes, and community contributions. My main goal in the use of purposive sampling was to focus on particular characteristics of my study participants, which would assist me in answering my primary research question. Patton (2002) stated that researchers who use purposive sampling choose participants based on study purpose with the expectation that each participant will provide information valuable to the study. This method of sampling allowed me to decide what type of data to collect and to find people who were willing and able to provide relevant data based on knowledge or experience (Bernard, 2002).

I distributed surveys to informal marine program staff specifically involved in educational programming. I did not include informal marine program staff whose primary job duties were not related to educational programming (e.g., secretarial work, dining services, transportation, and grounds keeping). I collected completed surveys and stored them in a secure location at research institution.

Analyses

When analyzing qualitative data, the researcher looks for trends or themes (Creswell, 2008). After determining the amount of data and type of data, the researcher might code the responses to group the comments into categories. The researcher might also choose to identify sections of the text that best illustrate the themes. The researcher's first step in analyzing qualitative information is to generate codes. The next step is to select and organize the codes and generate themes and main categories. Codes can then be reduced by eliminating less important codes. During this stage, the researcher must decide which information is most significant and which information should be omitted from analyses.

Descriptive analysis is used to reduce the researcher's quantitative raw data down to an understandable level. Common methods include: frequency distributions, central tendency, and variability (Creswell, 2008). Inferential analysis assists the researcher in formulating conclusions about results of the study. Various statistical tests may be used to explore the relationships found in the researcher's data, including chi-squares, correlations, t-tests, and analyses of variance. I used Pearson correlation coefficients to examine associations between upper level program staff (Director and above) and mid-lower level program staff regarding beliefs about program STEM quality, effectiveness, diversity, and accessibility to underserved students.

In this mixed methods research, I collected quantitative and qualitative data. Data collection items comprised numerical item scores and transcripts. Descriptive analysis, inferential analysis, and major themes were merged using a matrix relating qualitative themes to quantitative variables. Interpretation allowed for consideration and discussion of how merged results produced a better understanding (Wittink, Barg, & Gallo, 2006).

Reporting and Study Limitations

I report my findings by providing interpretation, presentation and/or discussion of the results in the form of a Record of Study as defined in the Texas A&M University Graduate Catalogue. Yin (2008) recommended that the researcher organize the findings by answering a series of questions as follows:

- Has the primary research question been answered?
- Have the study objectives been achieved?
- What has been learned from the results?
- How can this knowledge be used?
- What are the strengths and weaknesses of the methodology used?

Convenience sampling was used in this study. Convenience sampling was employed for the following advantages: simplicity of sampling, data collection in a short time frame, and cost effectiveness. Although convenience sampling was chosen based on its advantages, it also presents some limitations. Study limitations in convenience sampling include high vulnerability to selection bias, unclear generalizability, and heightened level of sampling error. Increased or high self-selection is a possibility in convenience sampling; therefore the effect of outliers can be harmful. Outliers as described by Hatch and Lazaraton (1991) are considered as not belonging to the overall population. Larson-Hall (2010) regarded outliers as items which greatly differ from the majority of the data and believes they are troublesome for statistical methods in which normality of the distribution is required.

Creswell (2008) suggested that being in the field over time strengthens evidence by allowing researchers to compare interview data with observational data. Lack of a sufficient amount of time makes it impractical for the researcher in this study to observe participants in their practices. Prolonged engagement in the field was not a criterion used in selecting the study participants and therefore this is considered a limitation for this study.

CHAPTER IV

FINDINGS

This study was a mixed methods design. I collected data using both qualitative and quantitative research methods. I first describe the quantitative findings from the survey and Likert-scale data. Next I present the qualitative findings from the interview data.

Survey/Public Data

The five programs included in this study were located in the same geographic area and collectively served approximately 25,000 K-12 students annually. A fundamental goal in many communities is to assist citizens in obtaining abilities and tools to fulfill their desire to learn, including engagement in STEM. This perspective emphasizes the importance and contributions of informal science education networks (Falk, Randol, & Dierking, 2011). The Texas Gulf Coast region has many known informal science education providers, some of which specialize on certain topics of interest. In this study, informal science providers specializing in marine or ocean-oriented topics were researched. Informal science learning experiences produce positive impacts in providing learning experiences to diverse learners and motivating them to learn in formal and informal environments (Hofstein & Rosenfeld, 1996). In consideration of the significant contributions offered through informal science, I analyzed STEM opportunities provided by informal marine education programs in this geographic area to better understand accessibility of the programs to underserved student populations. The number of students served by each program (see Table 1) reflects all students served annually and does not specify percentage of underserved students. Survey questions were asked and interviews were conducted to better understand program accessibility.

Table 1

Program Assessment of Program Type, Number of Students Served, and Time Spent on STEM

	Type of Informal Program	Total Annual Number of Students Served	Time Committed to STEM Activities (minutes per week)
Program A	Non-Profit/University	7,000	121-180
Program B	Non-Profit	3,000	241+
Program C	Non-Profit	4,000	241+
Program D	Non-Profit	2,000	61-120
Program E	Government/University	8,600	121-180

Additional survey questions were asked for program assessment purposes to better understand program STEM facilitators, approaches to incorporating STEM, and instructional strategies (see Table 2). While all of the programs included in this study have an informal marine-oriented focus, they deliver different types of programming. Program A's activities conducted from September-March consist of hosting incoming school groups for marine-oriented field trips, classroom visitations, and conference presentations. Activities conducted from April-August consisted of hosting incoming school groups for field trips and summer camp operations. Program B's staff worked with students and educators to better inform them of their local watershed. Program B designed activities focused on environmental education. Program B provided a hands-on habitat education program that allowed the students to participate in restoring local bay environments by collecting and planting marsh grass. Program C's premier program for students and teachers offered field labs via kayak, vessel, or walking that provided application of hands-on, real-world interactions that combine art and science in interpretation of the current and historical significance and uses of estuaries, barrier islands, and the ocean. Program D's activities focused on engaging students in STEM-based curriculum and connecting classroom learning with the real-life marine and maritime world. Program D provided hands-on activities while working together as a crew to explore the wonders of the sea aboard their 100-foot floating classroom. Program E offered programs such as student competitions, seminars, workshops and publications, that helped formal and informal educators become aware of the benefits of effective environmental STEM education. Program E worked to ensure students and educators were exposed to opportunities to participate in STEM and active stewardship programs.

Table 2

Program Assessment of STEM Facilitators, Content, and Instructional Strategies

	Type of Staff as STEM Facilitators	Approach to Incorporating STEM Content	Incorporated Instructional Strategies
Program A	Informal Educators College Students Volunteers	Separate Curricula Integrating Elements of STEM into Existing Curricula	Project-Based Learning Inquiry-Driven Learning Student-Centered Learning Hands-On Learning
Program B	Informal Educators College Students Volunteers	Integrating Elements of STEM into Existing Curricula	Project-Based Learning Inquiry-Driven Learning Student-Centered Learning Hands-On Learning Integrated Studies Service Learning
Program C	Informal Educators Instructional Day Teachers (STEM)	Integrating Elements of STEM into Existing Curricula	Project-Based Learning Inquiry-Driven Learning Student-Centered Learning Hands-On Learning Integrated Studies Service Learning
Program D	Informal Educators College Students Instruction Day Teachers (STEM and non-STEM) Volunteers	Separate Curricula Focused on STEM Integrating Elements of STEM into Existing Curricula	Project-Based Learning Inquiry-Driven Learning Student-Centered Learning Hands-On Learning
Program E	Informal Educators College Students Volunteers	Separate Curricula Focused on STEM Integrating Elements of STEM into Existing Curricula	Project-Based Learning Inquiry-Driven Learning Student-Centered Learning Hands-On Learning

Likert Scale Data

I created two sub-dimension mean scores by calculating a composite score from four or more Likert-type items. Individual items had five response alternatives: (1) Strongly Disagree, (2) Disagree, (3) Neither Agree nor Disagree, (4) Agree, and (5) Strongly Agree. First sub-dimension items used to assess program STEM quality include statements such as “I am confident the program provides high quality STEM activities for students” and “I am confident the program has leaders highly qualified to administer effective STEM activities to students. Next sub-dimension items used to assess program accessibility include statements such as “I am confident the program is proactive and successful in making programs financially accessible to underserved students” and “I am confident the program is doing enough to provide accessible programming to underserved students.” Items summed with other related questionnaire items provided a quantitative measure of a character or personality trait.

Descriptive statistics included the mean, median, and mode for central tendency and standard deviations for variability. The mean for program STEM quality sub-dimension is 4.38 and the mean for program accessibility sub-dimension is 3.74 (see Table 3).

Table 3

Descriptive Statistics

Likert Scale Items	Mean	SD	Median	Mode	Variance
Program STEM Quality	4.38	.91	5	5	.83
Program Accessibility	3.74	1.22	4	5	1.49

Note. Mean calculated from participants’ scores rated 1 to 5.

Data analysis procedures included inferential and graphical statistics. I analyzed the responses for program STEM quality and responses for program accessibility. When examining the scatterplot (see Figure 1), I looked for three things: relationship, direction, and strength. Analysis of these two items yielded a Pearson product moment correlation coefficient, r =.43.

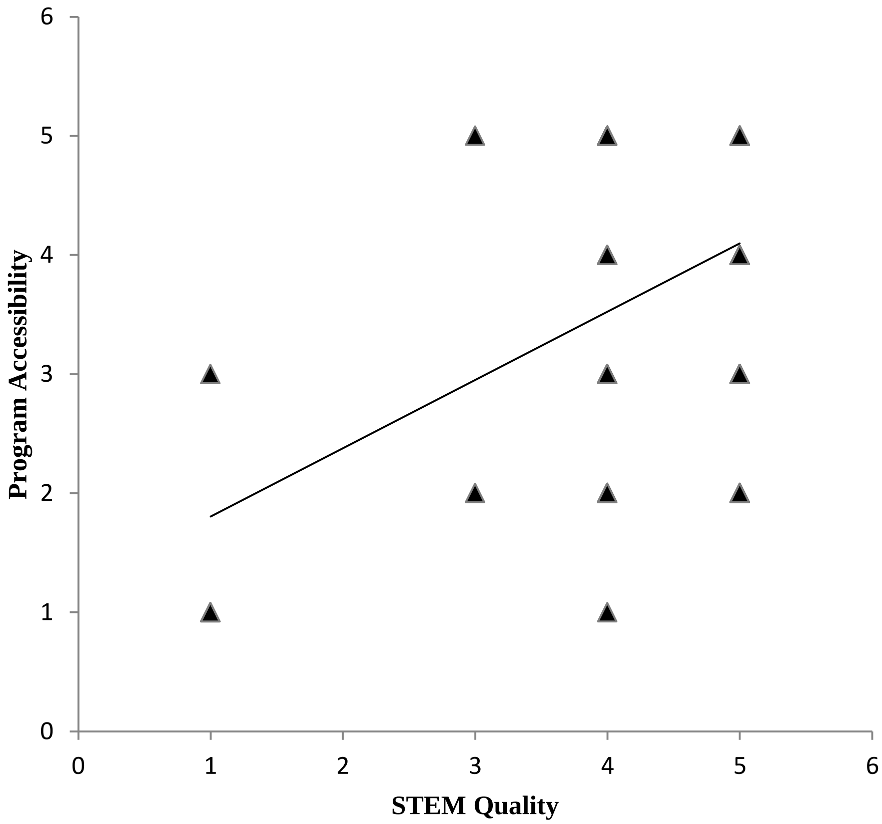

Figure 1. Linear regression depicting the relationship between program STEM quality and program accessibility.

The degree of the Pearson correlation coefficient determines the strength of the correlation. I used general guidelines provided by Cohen (1988) to determine the Pearson correlation coefficient (r = .43) means there is a medium or moderate positive correlation between program STEM quality and program accessibility (N=22).

I also analyzed responses from the program assessment questionnaire in which participants (N=22) were asked their perceptions of challenges faced by formal educators in relationship to implementing STEM activities (see Figure 2). Among all of the concerns listed, limited funds ranked the highest at 86.36%. Additional perceived challenges included lack of facilities, limited time for STEM, and limited professional development. Challenges that ranked the lowest included limited student interest at 13.64%. The challenge marked as 'Other' also ranked at 13.64% and included comments such as "There is a lack of funding for buses. Teachers don't want (or can't) take students out of the classroom." Participants also commented that "Standardized testing reduces the flexibility of teachers to engage in programs outside the classroom."

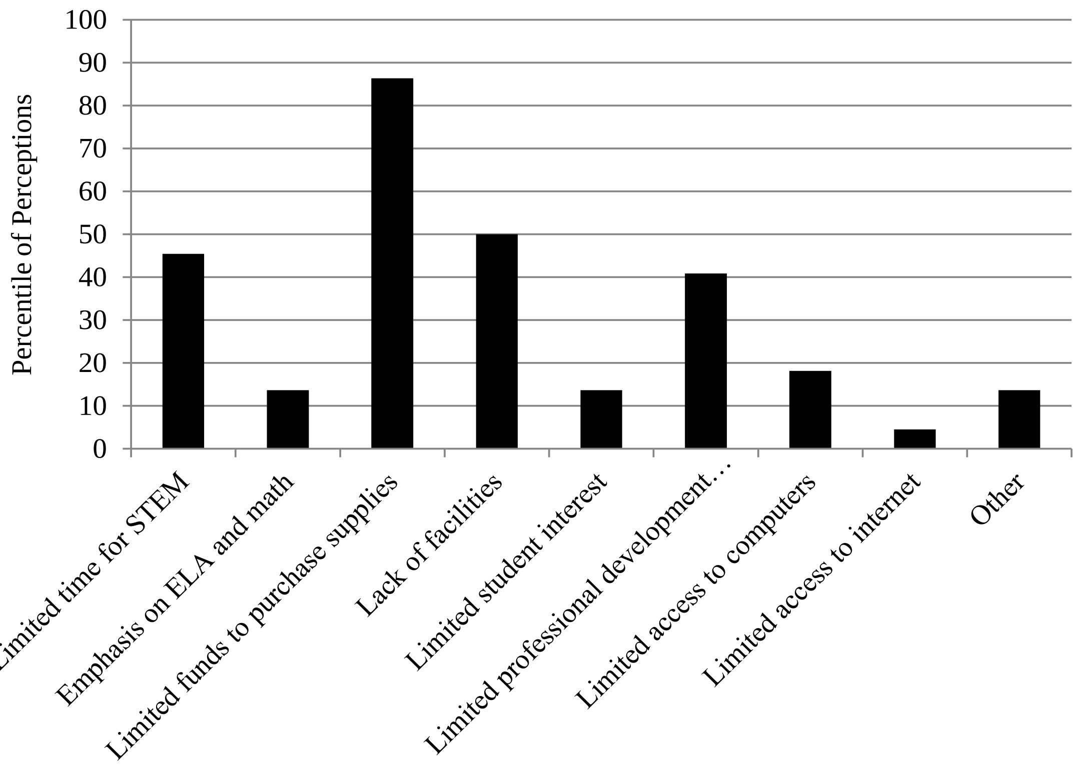

Figure 2. Percentile of the perceptions of challenges formal educators face in relationship to implementing STEM activities.

Researchers are trying to better understand the need to develop more collaboration between formal schools and informal science providers. Stakeholders are beginning to realize that increasing the number of informal programs is not as essential as ensuring the quality of informal programs. Public schools and informal science institutions need to be more mindful with resources in order to build on the strengths of resources to make science learning more meaningful (The Center for Informal Learning and Schools, 2004). The survey respondents in this study rated their program STEM quality highly. While their survey ratings for quality were high, their survey ratings for accessibility were lower. When asked about confidence in program STEM quality only 6.8 percent of item responses were rated a three or below (1 - Strongly Disagree, 2 - Disagree, 3 - Neither Agree nor Disagree), compared to 41% of item responses rated three or below for confidence in program STEM accessibility. There is agreement and commitment among researchers and program providers to broadening accessibility and participation in informal science learning. Programs designed to improve accessibility for diverse groups do exist. However, it is evident that many efforts for inclusion often to not accomplish desirable outcomes (National Research Council, 2009).

Interview Data

I interviewed five participants. One representative from each of the five considered the program director level or at a higher level participated in the interviews. I recorded the interview data on a digital recording device. The recordings were transcribed verbatim. I read the transcriptions for analyses. I used word frequency tools and generated codes with short phrases during my first reading of the transcriptions. The five interviewees were selected due to their positions within informal marine education programs. These upper level personnel were directly involved in the development, organization, supervision, and delivery of informal marine science and STEM content.

In my analysis, I used the constant comparative method. I discerned themes that developed from the data in conjunction with NVivo software. According to Strauss and Corbin (1998) the constant comparative method combines thought processes with exchange between data and researcher when trying to understand the data. The constant comparative method comprises four stages. The first stage compares incidents to themes and then in the next stage the themes are integrated. The last two stages include defining and writing theory (Glaser and Strauss, 1967). I used the constant comparative method as described by Strauss and Corbin (1990) to review sentences and sections of the transcribed interviews to determine which codes fit the concepts. Subsequently, I combined several codes to produces themes. Participants' opinions and beliefs as informal marine educators provided the basis for my emergent theory. My objective was to present a clear picture of informal marine program providers and their actions in the context of program STEM quality and accessibility to underserved students in the Texas Gulf Coast region.

I used NVivo software to code each participant's transcribed semi-structured interview. I coded text from each participant's interview that reflected the themes critical to my research questions. The themes that emerged, identifying financial commitment (for participant), motivational STEM programming, meaningful STEM pathways, creating an environment of accessibility, and collaboration were derived from codes I assigned to the interview transcriptions (see Table 4).

Table 4

Themes and Codes Emerged from the Interview Transcriptions

Theme: Identifying financial commitment (for participant) • Code 1: Tuition-based • Code 2: Non-tuition based • Code 3: Mixed
Theme: Motivational STEM programming • Code 1: Engagement • Code 2: Encouragement • Code 3: Sustaining interest
Theme: Meaningful STEM Pathways • Code 1: Hands-on approach to learning • Code 2: Unique experiences • Code 3: Personal connections
Theme: Creating an environment of accessibility • Code 1: Funding sources • Code 2: Dissemination of information • Code 3: Gaining trust in the community/schools
Theme: Collaboration • Code 1: Networking • Code 2: Sharing resources and partnering • Code 3: Collective capabilities and responsibilities

Identifying Financial Commitment

The interviewees reported that their programs require different levels of financial support the students' parents. The interviewee from Program A described mixed financial commitments for their program participants by stating that "Most of our programs are tuition-based and actually geared toward a target audience of students with parents and families who have the financial means to support extracurricular activities."

The interviewee from Program A went on to say that their program did also write and receive grants to provide non-tuition based programs for underserved students; however that was not a top priority for the program. The interviewee showed an interest in improving financial accessibility by stating "The non-tuition based programs, in my opinion, are a lot more beneficial because the students are invested and passionate about a particular discipline they are interested in." Interviewees from Programs B, C, and D also indicated a mix of financial commitments required of participants. The interviewee from Program B stated "This coming 2016-2017 school year, we are going to start adding a cost to our programs. However, we are going to set it up in a way that we will still have scholarships so if a school can't afford the program, and then they can fill out a scholarship application." The interviewee from Program C explained "We have programs that are standard rates per group. So a teacher or group leader could get two components of a program and it's a set price. We charge by class." The interviewee went on to add "We do apply for a lot of grants so that we can provide our programming for free." The interviewee from Program D stated "the range of the cost goes from free, which is the volunteering side of things, up to about $3,800 for one of our excursions." The interviewee for Program E was the only interviewee who stated "We really don't do a lot of fee based programs that I can think of."

Motivational STEM Programming

The participants reported that they aim to provide motivational STEM programing to the students. The interviewee from Program D explained providing motivational STEM programming when describing their ideal learner by stating "We look for someone who has a passion. What we look for is that spark. I want to strike some sort of spark inside of them and get them interested. So ideally, this candidate would be a listener; they participate in our activities and are willing to participate. They don't have to be a leader, they could be a follower. We are trying to build their passion and their character." The interviewee from Program A was interested in programming that motivated students by exposing them to different STEM-related career possibilities. She stated "some of the students who might feel that they might not go on to be a doctor or be a Ph.D. candidate - knowing that something they want to focus on is still in the STEM field. It's a high demanding and lucrative job. That it's a possibility for them." The interviewee from Program B reported that they motivate students by involving all types of learners. "We want to make sure that we are involving every type of learner. So you might have somebody who's a visual learner and you might have lots of displays that go with that. Or you might have somebody who's a tactile learner so we have lots of hands on components to it." The interviewee from Program C explained how their programs provide motivational STEM programming by cultivating a custodial sense of community pride and responsibility. "For our students that are local, we are taking them outside, it's an explorential activity where they are learning about what's local to them and why it's important to protect their local ecosystem, their city, their local economy." The interviewee from Program E explained that motivational STEM programming is important in capturing the interest of underserved students "The kids that don't have the opportunities that perhaps of being outdoors or having that experience of being in the marine environment."

Meaningful STEM Pathways

The participants reported that students would need hands-on and convincing experiences in order to make meaningful connections with STEM fields. The interviewee from Program B illustrated meaningful STEM pathways by stating "Anything can be STEM almost these days and so how you make it meaningful is that you give students a personal connection. And you give them the opportunity to not only have that personal connection, but a reflection period as well." The interviewee from Program A explained that meaningful STEM pathways included steps to expose underserved students to possible careers. She said "The first would be building bridges. For example our non-tuition fee based program, these would be our students that don't have the financial stability or the proper exposure academically or personally for people in the STEM industry or field. So we are actually allowing the students to go behind the scenes and see a different type of industry from what they are used to." The interviewee from Program C illustrated similar meaningful STEM pathways by stating "I think that the fact that most of these kids wouldn't have the opportunity to do that it's a transformational opportunity for them." The interviewee from Program D described meaningful pathways by helping students build something on their own "For the engineering part, we like to do wind anemometers because that's probably another way to get kids to own something so they will become more immersed in the program because they have constructed something of their own that they really like." The interviewee from Program E explained that their programming facilitated STEM pathways through professional development for formal educators. "We have in the past offered teacher workshops that fit in with STEM-based programs. It introduces the teachers to marine science. What it does is it makes the teachers more comfortable in using the marine environment in the outdoor as a classroom in teaching in it."

Creating an Environment of Accessibility

Most participants reported progress and challenges in creating an environment of accessibility within their programs. The interviewee from Program C discussed creating an environment of financial accessibility by stating "I think that we all work really hard to find resources to help these students because we understand everybody should have the opportunity to learn about their environment. Not just those that their family can pay for." The interviewee from Program D stated "So we actually pride ourselves in is trying to provide for the people who are not financially equipped. So trying to reduce costs where we can, that's what we try to go for." The interviewee from Program B expressed frustration in encouraging formal educators to apply for scholarships/assistance by stating "How do you get these teachers or these leaders or instructors whoever they might be to fill out this application? If they just go in and they see it has a cost and even though they see right underneath that but there's a scholarship you can fill out and they won't take that extra step, does this mean that we need questions for principals or leaders or teachers that ask "how can we make this easier?" The interviewee from Program A stated "It's really about identifying your audience, how to target them, how to get them interested in finding the proper organizations and companies that will sponsor you financially and building those bridges." The interviewee from Program E explained accessible programs by stating "We do a lot through the schools and libraries and stuff.

We really try to target low income areas. We try to target those areas where maybe the kids haven't been introduced to the marine environment or people who have careers in marine science."

Collaboration

All of the program interviewees agreed that program STEM quality and accessibility for informal marine education programs serving the Texas Gulf Coast region could be improved upon by increased collaboration amongst each other. The interviewee from Program B stated "I think considering that the whole Galveston bay area is mostly of water, it seems fitting that we should have a group of those of us that are focused with the bay and the gulf and the bayous. There's so much opportunity there and it's much easier for us to align ourselves on grants. So yes, I would very much like to see increased collaboration and all of this area is pretty much underserved underrepresented population." The interviewee from Program A stated "I think increased collaboration would be a great idea, not only will we be able to in sense reach a larger audience but will also be able to utilize our resources a lot better. I feel sometimes a lot of organizations will be permanently going for the same objective or same goal but just using different methods to get there. So we would be able to double our resources and utilize our employees for more beneficial purpose." The interviewee from Program E expressed a strong interest in increased collaboration by stating "I think that we can maximize the impact that we have if we are working together and coordinating. We can figure out where there are the gaps and how we can fill those gaps in places where we're either not targeting specific audiences or not hitting topic areas."

Data Interpretation

In a study of using manual and digital interview analysis techniques, Welsh (2002) explained that to achieve desirable results, researchers should not completely rely on manual or digital methods and instead combine their best elements. Use of NVivo allowed me to store my interviews as sources and highlight sentences and partial paragraphs from each interview and then create nodes (in NVivo terms, a node is coded data related to the study). This approach helped me organize relevant data and eliminate irrelevant data. After finishing the coding process, I reviewed the nodes in the node browser multiple times using the constant comparative method to look for themes that emerged from the study. I then manually reshaped the codes, assigned them to a proper theme, and presented them in a format that was easy to read and understand.

The primary research question in this study is: What are the roles and characteristics of informal marine education programs in engaging underserved students of the Texas Gulf Coast in out-of-school STEM activities? While coding the interview transcripts, I created a code for engagement after highlighting sentences and partial paragraphs and combined it with two other codes: encouragement and sustaining interest. These three codes made up the theme called motivational STEM programming (see Table 4). All of the interviewees had a high level of contributions to all three codes within this theme as well as to the related theme called meaningful STEM pathways. Interviewees indicated that motivational STEM programming leads to meaningful STEM pathways. Jarvis and Pell (2002) stated “the process of enabling young children to start a lifelong interest and understanding of science in the wider world may be improved by the provision of out-of-school experiences" (p. 980). Interviewees had strong interest in promoting lifelong interest and understanding of science by providing engaging programs, encouraging participation, and sustaining interest. The interviewee from Program B stated in reference to working with schools and teachers who have participated in their programs "I hope they come out of that experience understanding that it's really important for students to get outside the classroom and engage in to experiential type programs." The interviewee from Program A stated "the students are actually gaining something that can shape their life for the long haul" when speaking of engaging curriculum and activities possible in informal marine education (e.g., exposure to and learning seafaring skills while conducting STEM-related experiences at sea).

Understanding the existence of motivational STEM programming provided by informal marine education programs serving the Texas Gulf Coast was straightforward to me. Lack of funding in formal and informal education to provide STEM activities to underserved students was also a straightforward challenge. How the programs specifically engage underserved students with their programming was not as clear. Interviewees spoke highly of the engaging and encouraging activities their programs provide, ranging from simple dissections to week-long summer camps on a college campus. However, in order to operate and remain financially stable, all but one of the interviewees explained necessary fees and/or tuition for many of their activities. The themes that helped me understand underserved students and out-of-school STEM activities were financial commitment (for the participant) and creating an environment of accessibility (see Table 4). Program fees in some cases are paid by the individual participant and in some cases paid fully or partially by grant money. The interviewee from Program D stated "the range of the cost goes from free, which is the volunteering side of things, up to about $3,800 for one of our excursions." The interviewee noted that free programming, such as organized volunteer beach clean-ups, appeal to schools that lack funding for their more expensive field trips (e.g., research vessel trips.) While the interviewees again expressed pride in trying to provide tuition-free programming, such endeavors tend to rely heavily on unguaranteed grant money.

Interviewees and survey participants from each of the five programs described different platforms from which they offer their programs, however there were similarities found in their opinions of informal marine education:

- Belief in the ability to offer engaging, marine-oriented curricula
- Notable agreement in the importance of incorporating STEM content
- Funding challenges in meeting the needs of underserved students
- Concurrence for an increased effort in networking and partnerships amongst programs

I identified more similarities of opinion within and between the programs than differences; however some discrepancies and difference of opinions did emerge. The most noteworthy discrepancies came from comparing interview transcripts and the following Likert item:

- I am confident the program is doing enough to provide accessible programming to underserved students.

The interviews were conducted with staff classified as ‘Director Level (or higher)’, meaning interviewees were ranked highly in their programs with considerably more responsibility and accountability. Surveys were completed by all levels of education staff (N=22). All five interviewees reported high levels of proactivity and pursuit in the provision of accessible programming for underserved students. Education staff did not seem as confident in program accessibility for underserved students as their program leaders did. When asked if they were confident the program was doing enough to provide accessible programming, seven education staff survey participants either strongly disagreed or disagreed, while four other survey participants were neutral. This means that half of the education staff members who participated in the survey do not feel confident their program is doing enough to provide accessible programming to underserved students.

CHAPTER V

DISCUSSION AND CONCLUSION

Discussion

In this mixed-methods study, I examined the informal marine education programs in the Texas Gulf Coast region and explored the practices they offer for underserved students in STEM fields. I collected survey data and conducted semi-structured interviews in order to explore the opinions and views of informal marine education program providers serving the Texas Gulf Coast. I analyzed participants' opinions of STEM opportunities provided by informal marine education programs from a specific geographic area to better understand accessibility of the programs to underserved student populations from the same geographic area. I employed a mixed-methods approach to connect trends and patterns within the programs while simultaneously uncovering subtleties within each program (Greene, Caracelli, & Graham 1989).

I addressed my primary research question by researching the roles and characteristics of informal marine education programs in engaging underserved students of the Texas Gulf Coast in out-of-school STEM activities. Addressing my primary research question was accomplished with the addition of several sub-questions. The sub-questions focused on how the programs in the study recognized equity and diversity, general characteristics of their STEM education practices, and staff member perceptions of the quality of STEM instruction and engagement in their activities.

Several roles and characteristics of informal marine education programs in engaging underserved students of the Texas Gulf Coast in out-of-school STEM activities emerged from the study. Participants in the study agreed that there is an incredible amount of STEM learning that occurs outside of formal education. They shared similar opinions regarding high levels of importance and responsibility in their roles. Their specific roles varied by designed environment (e.g., environment centers or aquariums) or program type (e.g., summer camps or after-school programs). Specific roles ranged from lower level program staff to upper level program directors and owners. More general roles are described as ranging from simple guiding of learners' experiences to highly organized, in-depth learner engagement. The study participants shared several characteristics. Each of the study participants noted the importance of engagement in the delivery of meaningful STEM programming. They described various ways in which they support learner engagement. Study participants explained that engagement is supported by providing influential STEM facilitators and unique approaches to incorporating STEM content and instructional strategies.

Study participants recognized equity and diversity in STEM education. They also supported expanding access to STEM opportunities for underserved students. Study participants noted the most considerable challenge in program accessibility as limited funding. They had varied perceptions of whether informal marine education programs were doing enough to provide access to underserved students. Whether study participants agreed or disagreed on this topic was overshadowed by interest and commitment in seeking opportunities to overcome challenges. Study participants' perceptions of the quality of STEM instruction and engagement in current informal marine education activities were all very high.

I would describe the characteristics of the STEM education practices operationalized by the informal marine education programs serving the Texas Gulf Coast as engaging, influential, and committed. The programs included in this study are derived from a community of informal marine educators who share a regional culture of rich maritime heritage and coastal influences. The programs share similar missions and have many commonalities of practice in designing, offering, and delivering marine-oriented curriculum (see Table 2). The characteristics of the STEM education practices in this study are similar to characteristics of informal science learning. Bell, Lewenstein, Shouse, and Feder (2009) stated that "Informal science learning, although composed of multiple communities of practice, shares common commitments to science learning environments that:

- engage participants in multiple ways, including physically, emotionally, and cognitively;
- encourage participants' direct interactions with phenomena of the natural and designed physical world largely in learner-directed ways;
- provide multifaceted and dynamic portrayals of science; and
- build on learners' prior knowledge and interests" (p. 298).

Conclusion

Informal STEM experiences are important for youth. Informal STEM experiences provide opportunities for science engagement in a meaningful way without involving formal education requirements (Falk & Dierking, 2010). These experiences seem to be missing for many young people living in underserved communities. Providing opportunities for underserved students to learn science and be introduced to STEM careers in atmospheres outside of school has been suggested as a method to improving accessibility in STEM (Falk & Dierking, 2010).

Bell et al. (2009) stated “Ensuring that the principles of informal science learning (e.g., learner choice, low-stakes assessments for learners) are sustained as out-of-school-time programs grow will require careful attention to professional development, curricula, and best practices” (p. 303). I believe that studying the roles and characteristics that support principles of informal science learning is fundamental in achieving accessibility and best practices. Informal learning has a smaller, yet powerful, set of guiding principles than formal learning. I believe that in order to maintain the authenticity of informal learning, informal program providers must continually assess their roles and characteristics. Bell et al. (2009) also concluded that while there is bountiful evidence related to learning in informal science environments, there are limited peer-reviewed outlets for publication dedicated to it. It is my hope that as informal science programs continue to grow that they look deeper at themselves in terms of program assessment and outcomes.

The National Research Council (2009) stated that STEM achievement in formal education is only part of what is required to engage meaningful experiences in STEM. Activities that thoughtfully engage people in informal learning are essential for STEM learning. Informal educational programs dedicated to improving science literacy take place in communities and science organizations and include self-organized science activities (National Research Council, 2009). These programs are growing in popularity and there is increasing evidence that organized, informal science programs inspire interest in science. Informal science programs may positively influence achievement in formal education and may expand participants' perceptions of STEM career options (National Research Council, 2009).

I agree with the National Research Council (2009) in that the number of informal education programs is growing, particularly informal programs offering STEM-related activities. In my community, many of the informal education programs offering STEM-related activities are marine oriented and located on the Texas Gulf Coast. Because the number of such programs is on the rise and the STEM engagement in informal learning environments is crucial for STEM learning, particularly in underrepresented communities, it is essential that these programs are providing proper and meaningful STEM activities.

Implications and Recommendations for Future Research

Hofstein and Rosenfeld (1996) stated a person's knowledge of science should not be limited to formal learning and restricting learning opportunities available to students can be harmful. Fensham argued that, "Informal and formal science experiences should be blended together to enrich the repertoire of learning opportunities. Such blending is necessary to meet the challenge of accessible science, providing science education tailored to diverse and heterogeneous populations of future citizens" (as cited in Hofstein & Rosenfeld, 1996, p. 107).

Variability in the success of informal education programs recruiting and engaging diverse learners is a topic of interest. A better understanding of informal STEM programs in historically underserved areas is needed to in better understand learning processes and to inform the design of learning experiences that meaningfully serve diverse communities (National Research Council, 2009). I recommend future research on informal marine education programs serving the Texas Gulf Coast. As Bell et al. (2009) suggested, improving the quality and quantity of evidence on science learning in informal environments is challenging. Research and program assessment efforts rely on all stakeholders, particularly those in informal program leadership positions. An increase in evidence may also yield an increase in accessibility for underserved students. A better understanding of science learning in underserved communities is needed to inform basic theory and to design meaningful learning experiences for diverse groups (Bell et al., 2009). I believe that additional research and published evidence would be beneficial in attaining grants and other funding necessary to provide accessible programming.

Based on the findings in this study, I suggest expanding to include additional stakeholders such as parents and students. I feel confident in the number of program sites included in this study; however this study could be expanded upon by including additional stakeholders. It is my opinion, that by including additional stakeholders, mixed-methods triangulation analyses would yield a more compelling overall measure.

This study initiated valuable dialogue between informal marine education providers serving the Texas Gulf Coast. Further dialogue and collaboration will occur in sharing the findings of this study with program participants. The creation of a specific and willing network of informal marine education program providers offers a diverse variety of educational resources and opportunities. Increased collaboration between the programs has unlimited potential in delivering educational benefits that have been historically limited in underserved student populations.

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APPENDIX A

IRB OUTCOME LETTER

DIVISION OF RESEARCH
Research Compliance and Biosafety

DATE: December 23, 2014

MEMORANDUM

TO: Bugrahan Yalvac
TAMU - College Of Education - Teaching, Learning And Culture

FROM: Dr. James Fluckey
Chair
Institutional Review Board

SUBJECT: Expedited Approval

Study Number: IRB2014-0539D

Title:	An Analysis of Informal, Marine-Oriented STEM Pathway Programs for Underserved Students of the Texas Gulf Coast
Approval Date:	12/23/2014
Continuing Review Due:	11/15/2015
Expiration Date:	2017

Documents Reviewed and Approved:

Submission Components

Study Document

Title	Version Number	Version Date	Outcome
Recruitment Materials3	Version 1.0	12/10/2014	Approved
ROS Summary_Dailey	Version 1.0	12/10/2014	Approved
Consent - Consent Form_Dailey_ROS	Version 1.0	11/14/2014	Approved
Semi-Structured Interview	Version 1.0	11/14/2014	Approved

Protocol1 2014-0539-pre-review clarification	Version 1.0	null	Approved

Document of Consent: Written consent in accordance with 45 CF 46.116/ 21 CFR 50.27

Waiver of Consent:

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186
Tel. 979.458.1467 Fax. 979.862.3176 http://rcb.tamu.edu

Provisions:

Comments: Researcher was responsive to requests of the Reviewer.

This research project has been approved. As principal investigator, you assume the following responsibilities:

1. **Continuing Review:** The protocol must be renewed by the expiration date in order to continue with the research project. A Continuing Review application along with required documents must be submitted by the continuing review deadline. Failure to do so may result in processing delays, study termination, and/or loss of funding.
2. **Completion Report:** Upon completion of the research project (including data analysis and final written papers), a Completion Report must be submitted to the IRB.
3. **Unanticipated Problems and Adverse Events:** Unanticipated problems and adverse events must be reported to the IRB immediately.
4. **Reports of Potential Non-compliance:** Potential non-compliance, including deviations from protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol must be requested by submitting an Amendment to the IRB for review. The Amendment must be approved by the IRB before being implemented.
6. **Consent Forms:** When using a consent form or information sheet, you must use the IRB stamped approved version. Please log into iRIS to download your stamped approved version of the consenting instruments. If you are unable to locate the stamped version in iRIS, please contact the office.
7. **Audit:** Your protocol may be subject to audit by the Human Subjects Post Approval Monitor. During the life of the study please review and document study progress using the PI self-assessment found on the RCB website as a method of preparation for the potential audit. Investigators are responsible for maintaining complete and accurate study records and making them available for inspection. Investigators are encouraged to request a pre-initiation site visit with the Post Approval Monitor. These visits are designed to help ensure that all necessary documents are approved and in order prior to initiating the study and to help investigators maintain compliance.
8. **Recruitment**: All approved recruitment materials will be stamped electronically by the HSPP staff and available for download from iRIS. These IRB-stamped approved documents from iRIS must be used for recruitment. For materials that are distributed to potential participants electronically and for which you can only feasibly use the

approved text rather than the stamped document, the study's IRB Protocol number, approval date, and expiration dates must be included in the following format: TAMU IRB#20XX- XXXX Approved: XX/XX/XXXX Expiration Date: XX/XX/XXXX.

9. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the FERPA administrator at the institution where the research will be conducted in accordance with the Family Education Rights and Privacy Act (FERPA). The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.
10. **Food:** Any use of food in the conduct of human subjects research must follow Texas A&M University Standard Administrative Procedure 24.01.01.M4.02.
11. **Payments:** Any use of payments to human subjects must follow Texas A&M University Standard Administrative Procedure 21.01.99.M0.03.

This electronic document provides notification of the review results by the Institutional Review Board.

DATE:	October 14, 2015
MEMORANDUM TO:	Bugrahan Yalvac TAMU - College Of Education & Human Dev - Teaching, Learning And Culture
FROM:	Dr. James Fluckey Chair, TAMU IRB
SUBJECT:	Amendment Approval

Study Number:	IRB2014-0539D
Title:	An Analysis of Informal, Marine-Oriented STEM Pathway Programs for Underserved Students of the Texas Gulf Coast
Date of Determination:	
Approval Date:	12/23/2014
Continuing Review Due:	09/01/2016
Expiration Date:	10/01/2016
Documents Reviewed and Approved:	Only IRB-stamped approved versions of study materials (e.g., consent forms, recruitment materials, and questionnaires) can be distributed to human participants. Please log into iRIS to download the stamped, approved version of all study materials. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area.

Submission Components

Title	Version Number	Version Date	Outcome
program assessment for informal marine educators	Version 1.0	09/30/2015	Approved
recruitment materials4	Version 1.0	09/30/2015	Approved
Consent	Version 1.1	09/30/2015	Approved

APPENDIX B

SEMI-STRUCTURED INTERVIEW PROTOCOL FOR INFORMAL MARINE EDUCATOR PROGRAM PROVIDERS

Participation in this interview is completely voluntary. Participants may stop or take breaks as needed. Participants may also withdraw their participation at any time without consequence. The interviewer will ask emergent questions during the interview as appropriate.

1) Please describe the tuition/fee-based programs you provide.
2) Please describe the non-tuition/fee-based programs you provide.
3) Who is the ideal learner for your programs?
4) If you provide non-tuition/fee-based programs, who are the participants of such programs?
5) How are the participants for your non-tuition/fee-based programs recruited?
6) How are informal, marine-oriented programs such as yours providing meaningful STEM pathways for your program participants?
7) How are your programs changing the way educators think about STEM in their own teaching practice?
8) As an informal marine educator in Texas, how are your programs and other informal marine-oriented programs in Texas serving youth who financially cannot attend such tuition/fee-based programs?
9) What type of communication exists between your program and other informal, marine-oriented programs operating in Texas?
10) What is your interest level in forming a group with other informal, marine-oriented program providers located in your area; with the purpose of discussing how all programs can work together to better provide STEM experiences for underserved student populations?

APPENDIX C

PROGRAM ASSESSMENT FOR INFORMAL MARINE EDUCATORS

Program Assessment

Please Check One:

Program Director Level (or higher)	
Program Staff Member or Volunteer	

1. Type of Informal Program (i.e. non-profit, museum)
____

2. Grade Levels Served: Elementary _____Middle School ______High School________
3. Funding Source: ASES / 21st Century /Self-Funded/ Other_______________________
4. Total Annual Number of Students Served:_________________________
5. Estimated number of students participating in STEM programs? Please indicate the approximate number by grade level.
K-2 ________ 3-5 ________ 6-8 ________ 9-12 ________

6. Please identify how students are selected to participate in the STEM-related activities offered at your site(s).
___Students choose to participate in STEM-related activities.
___All students rotate through STEM-related activities.
___By grade level
___Other:____

7. How much time do you plan to commit to STEM activities (in minutes per week)?
___0-30
___31-60 minutes
___61-120 minutes
___121-180 minutes
___181-240 minutes
___241+ minutes

8. What type of staff do you intend to have as your STEM facilitators?
___High school students
___Informal Educators (OST program staff)

___College students
___Instructional day teachers (non-STEM)
___Instructional day teachers who specialize in science, technology, engineering or math
___Museum staff
___Volunteers
___Other:

9. Please describe your overall approach to incorporating STEM related content into daily learning activities. That is, in the activities where Science, Technology, Engineering, and/or Math appear, which of the following best describes how these disciplines are integrated?
___We use separate curricula that is focused on the discipline (i.e., Science, Technology, Engineering, Math)
___We integrate an element of the discipline into something we are already doing.
___We do not incorporate STEM related content into daily learning activities.

10. Which stakeholders do you consult when making decisions regarding after school/informal programs? Check all that apply.
___School District Administrators (District Decision)
___Principal (School Decision)
___Credentialed Academic Liaisons (Site Decision)
___Community Based Organization
___Site Coordinators
___Informal Educators (program staff)
___Other, please describe____

11. Decisions regarding after informal program curricula are made based on data and identified student need (i.e. API, AYP, STAR, CELDT, Teacher and student surveys)
___Yes If so, what data is utilized:
___No

12. Describe the alignment of informal program curricula with the instructional day. Check all that apply.
___Informal leaders coordinate with the District Director of Curriculum and Instruction
___Informal programs are included in site level professional learning communities
___Informal programs are included in district professional learning communities
___Informal program curricula is aligned with the pacing guide and/or grade level content standards

___Informal program curricula is aligned and supported with the practices of Common Core
___Informal program curricula is aligned and supported with the practices of Next Generation Science Standards
___Other, please describe____

13. Does the informal program curricula identified above incorporate the following instructional strategies? Check all that apply.
___Project-based learning
___Inquiry-driven instruction
___Student-centered learning
___Hands-on learning
___Integrated Studies
___Service learning
___Other, please describe

14. To your knowledge, what challenges do schools your serve face in relationship to implementing STEM activities? Check all that apply.
___Limited time for STEM
___Emphasis on ELA and math
___Limited funds to purchase supplies
___Lack of facilities
___Limited student interest
___Limited Professional Development Opportunities
___Limited access to computers or tablets
___Limited access to internet
___Other Explain:

15. Do you have established STEM partnerships with any of the following to strengthen STEM offerings? Check all that apply.
___Institutions of Higher Education (colleges and universities)
___Informal Learning Institutions (science centers, aquaria, zoos, etc.)
___County Offices of Education
___Federal Funding Agencies (NSF, NASA, etc.)
___Community-Based Organizations
___Local Business Organizations (Business Roundtables, etc.)
___Community Service Organizations (Kiwanis, Rotary, etc.)
___Local Individual Businesses

___Foundations (including educational foundations)
___Local Government Agencies
___Other Explain:
___None of the above

16. Do partners provide any of the following opportunities for exposing children to career options in STEM-related fields? Check all that apply.
___Mentorship regarding STEM
___STEM Internships
___STEM Apprenticeships
___STEM Career Awareness
___Exposure to College Degrees in STEM (i.e. chemical engineering)
___Exposure to Professionals in STEM Careers

17. Are there defined roles and responsibilities for STEM partners? If so, what are they?
___Yes Explain:
___No

18. Please complete the survey on the following page. The survey contains 12 statements that all begin with “I am confident…”. Each statement should be ranked according to how much you agree or disagree with it by placing an ‘X’ in the appropriate box. Use the following scale:

(**1**)=Strongly Disagree
(**2**)=Disagree
(**3**)=Neither Agree nor Disagree
(**4**)=Agree
(**5**)=Strongly Agree

(1)=Strongly Disagree (2)=Disagree (3)=Neither Agree nor Disagree (4)=Agree (5)=Strongly Agree	1	2	3	4	5
I am confident:					
1.) the program provides high quality STEM activities for students.					
2.) I produce high quality work.					
3.) the program inspires student interest in STEM.					
4.) I inspire student interest in STEM.					
5.) the program has leaders highly qualified to administer effective STEM activities to students.					
6.) in my STEM content knowledge.					
7.) the program supports diversity in education.					
8.) in my ability to educate and inspire students of diverse backgrounds.					
9.) the program is proactive and successful in making programs financially accessible to underserved students.					
10.) in my ability to help provide accessible programming to underserved students.					
11.) the program is doing enough to provide accessible programming to underserved students.					
12.) that other informal marine education programs serving the Texas Gulf Coast are doing enough to provide accessible programming to underserved students.					