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Science Inquiry in Informal Settings

Michelle Elizabeth Gomez Ms.
Louisiana State University and Agricultural and Mechanical College, mgomez8@lsu.edu

SCIENCE INQUIRY IN INFORMAL SETTINGS

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ABSTRACT

This qualitative research study aims to answer the question of whether or not informal learning settings, such as museums and zoos, are beneficial to students' understanding of new science concepts and the nature of science. The researcher uses the term, "informal educators," to refer to the participants because they are educators who teach in settings outside of a school setting. This study focuses on four informal educators that are employed at four different informal learning settings in South Louisiana, but specifically how the informal educators' instruction complements classroom instruction, how informal educators incorporate inquiry within their science instruction, and what image of science informal educators hope to portray to the guests at their museums or zoos. Data was collected through interviews with informal science educators, observations of the informal settings' web pages, and documents of instructional materials offered by the informal learning site. After the data were analyzed using the structural coding and open coding method, the findings revealed that two out of the four informal educators were willing to work with formal educators to make sure that they are covering topics in their museum or zoo that complemented the instruction that students were learning in the classroom. The informal educators' responses to interview questions revealed that all of them incorporate inquiry throughout science instruction using a hands-on learning approach. Additionally, it was revealed that the informal educators had varying views on what image of science that they hoped to portray in their museum or zoo.

CHAPTER 1. INTRODUCTION

Background

When I think back to my years in elementary and secondary school, I remember that field trips were one of the highlights of my educational experiences. Field trips always filled my classmates and me with excitement as we were given the opportunity to have fun and explore in a real-world environment, outside of the classroom. Children, from a young age, are naturally curious; they learn from observation and exploration. “While formal science learning experiences are important and can be modified to be inclusive of diverse students, informal environments make different affordances of relevancy by providing students with greater voice and choice to determine the nature of their science experiences” (Verma et. al., 2015, p. 269). Field trips can be the perfect setting for students to learn more authentically, in a real-world setting, that is much less structured than a typical classroom.

Now, as an elementary teacher, I have become very interested in knowing and understanding the learning benefits of students being exposed to experiences outside of the four walls of a classroom. With many formal educators taking their students on field trips each school year, it is important that these experiences are used as learning experiences that complement classroom instruction and not simply as leisure experiences (Tunnicliffe, 2007).

Rationale

The purpose of this study was to investigate science programming offered in informal settings, especially as that programing is planned to incorporate the nature of science and inquiry-based instruction. As a formal educator, I was interested in researching the thoughts and views of informal science educators in informal settings, such as museums and zoos.

Research Questions

I addressed the following research questions in this study:

1. How does informal educators' science programming compliment classroom instruction?
2. How do informal educators incorporate science inquiry in their science programming?
3. What image of science do informal educators hope to portray to students?

In considering these research questions, I use the term, "informal educators," to refer to the participants because they are educators who teach in settings outside of a school setting.

Methods

This qualitative study focuses on four informal educators at four different informal learning settings in South Louisiana. I collected the following data to answer the research questions: face-to-face or phone interviews with the participants, observations of informal settings' websites, and analysis of instructional activities provided to guests through the websites. The data collected from the study were analyzed using structural and open coding.

Throughout this study, the researcher experienced several limitations. Since the participants are all employed at informal settings in South Louisiana, the data collected may not apply museums or zoos in other parts of the state, country, or world. Additionally, the small sample size and longitudinal effects have also served as challenges for the researcher.

Definition of Key Terms

Informal learning is learning that takes place outside of school settings. These places could include students' homes, museums, zoos, national parks, and many more (Kola-Olusanya, 2005).

Nature of science is defined as “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992, 2007)” (Lederman, 2013, p. 140).

Inquiry-based learning allows students to learn through discovery and hands-on learning experiences.

Informal Educators are any educators who teach outside of a school setting, these settings include homes, national parks, museums, zoos, and many more (Kola-Olusanya, 2005).

Summary

This study focuses on four informal educators at four different informal settings in South Louisiana and their views and beliefs regarding science. All participants signed a consent form, which stated an overview of the study before the remaining of the study continued. Data for this study include participant face-to-face and phone interviews (See Appendix E), an observation of the informal settings’ websites (See Appendix C), and an analysis of the resource materials found on one of the websites (See Appendix D). After data collection, data sources were transcribed, if appropriate, and coded in order to find connections among the three pieces of evidence. Results revealed that through collaboration between formal educators and informal educators, the informal settings’ science programming can complement classroom instruction. It was also found that informal educators incorporate science inquiry into their science programming through a hands-on learning approach and each informal educator had varying views of the image of science that they wish to portray in their museum or zoo.

CHAPTER 2. REVIEW OF LITERATURE

A growing body of literature has established that students are able to successfully learn new concepts in environments other than the traditional classroom setting. Informal learning sites, such as zoos and museums, provide students with authentic learning experiences that students simply do not have access to in a formal classroom setting. Students possess a natural curiosity and informal learning sites allow them to express their curiosity through questioning and exploration in order to learn new concepts. Through the reading of the literature and my own interests, I arrived at these three research questions:

1. How does informal educators' science programming complement classroom instruction?
2. How do informal educators incorporate science inquiry in their science programming?
3. What image of science do informal educators hope to portray to students?

This literature review will focus on three major themes which surfaced frequently throughout the process of reviewing the literature relevant to my research questions. The themes include informal learning, nature of science, and inquiry-based learning. While this literature presents itself in a variety of contexts, this review will primarily focus on how students' knowledge of new scientific concepts is benefited by learning in informal environments that include a solid representation of the nature of science and allows students to learn through inquiry-based methods.

Informal Learning

Typically within a formal classroom setting, science instruction is mainly teacher-directed, within a structured environment. However, "other sites exist outside of the classroom that allow for student generation of scientific knowledge. These sites provide opportunities for linguistic and social interactions to play a powerful role in situating students' science learning experiences" (Verma et. al., 2015, p. 268). Informal learning environments allow for students to learn in a less-structured environment and grants them the opportunity to explore and discover new concepts through their experiences.

Informal learning environments, such as zoos and museums, are visited by many schools and families each year. "In North America, about 140 million people visit zoos and aquariums annually, which is more than the annual combined attendance of the top four organized sports: baseball, basketball, football, and hockey (Association of Zoos and Aquariums, 2012)" (Schwan, 2014, p. 70). Visits to zoos and museums have the possibility to spark interests in science content as students are able to experience new concepts first-hand through their authentic experiences. For instance, students benefit from learning in informal environments, where they are able to drive their own instruction (Kola-Olusanya, 2005). Kola-Olusanya (2005) examined students in various informal learning environments such as their homes, museums, zoos, national parks, and many more; and focused on how the students benefited from a "free-choice" learning environment by driving their own learning experiences. Kola-Olusanya's (2005) work demonstrated that in an informal learning environment students have the opportunity to interact with the world around them, as well as interact with peers and adults in the community. "Children develop unique and direct ways of knowing the natural world through discovery and interaction using their concrete experiences (Fleer & Hardy, 2000; Malone & Tranter, 2003)" (Kola-Olusanya, 2005, p. 303). It was found that when students are able to learn in a free-choice learning environment they are much more motivated to learn new concepts and due to their increase in interest, they are much more likely to stay focused and retain newfound information.

Within a free-choice learning environment, which is often found in museums and zoos, it is important that educators and other adults do not miss important opportunities to teach their students about what they are experiencing during these learning experiences. Tunnicliffe (2007) followed a group of teachers with students and parents with their families (children's' ages ranging from 5 to 11) in order to examine their 'unit of conversation' throughout their visit at a zoo. By using a systematic network of grouping and categorizing the data found in conversation, Tunnicliffe (2007) found that both the school groups and the families exhibited the same amount of knowledge about the animals in the zoo. This knowledge was described to be very basic knowledge, such as simply naming each type of animal. With the visit to the zoo, families usually use the experience as a leisure activity whereas school groups use it as a learning activity; therefore, the researcher was shocked that there were no significant differences in the ways that both groups discussed the learning experiences during their visit. Although it was noted that when discussing the types of animals, the school group was more likely to discuss physical traits of the animals, such as saying that a tiger had stripes, it was still a very basic conversations about the animals. Tunnicliffe (2007) concluded that educators, in these informal environments, often missed opportunities to discuss science concepts using authentic experiences.

In order for students to benefit from informal learning, educators must first realize the importance of exposing their students to this type of learning and how to do it successfully. Therefore, Neatherly (1998) analyzed teachers' perspectives of informal learning after they received science instruction from two exhibits: a wildlife refuge and a zoological sanctuary. Teachers were given this opportunity to learn through informal experiences in order to provide an example of how these experiences can be presented successfully to students and hopefully foster a positive experience for the teachers. Findings from Neatherley's (1998) study show overall, that teachers felt the informal education guides would have a positive impact on the learner's attentiveness. Additionally, teachers rated informal learning settings as a potentially valuable adjunct to classroom instruction. Teachers also agreed that learning in informal settings promotes retention of knowledge.

As found in the literature regarding informal learning, these experiences in learning environments outside of the classroom allow students to explore and learn in authentic, real-world situations. However, educators must also take advantage of these informal learning experiences and make them relevant and meaningful for their students. Taking field trips to museums and zoos often brings a lot of excitement and interest to students, which is important, but it is equally important, if not more important, that educators use these authentic and rich learning experiences to create teachable moments that students are unable to experience in the formal classroom setting.

Nature of Science

While students are having authentic learning experiences in informal environments, it breeds the perfect opportunity for students to develop informed conceptions of the nature of science. According to Lederman, the nature of science (NOS) "typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992, 2007)" (Lederman, 2013, p. 140). Science is not simply memorizing facts and following a linear list of rules and procedures, which is what many people think science is due to their experiences in the classroom. Instead, science is questioning, testing ideas, and discovery in the natural world. Science is not constant, it is forever changing. Aspects of the NOS that are accessible to elementary and secondary students include: 1) science knowledge is tentative 2) science knowledge is empirically based 3) science knowledge is subjective 4) scientific knowledge is partly the product of human inference, imagination, and creativity 5) science knowledge is socially and culturally embedded 6) the distinction of observations and inferences, and 7) the functions and relationships between theories and laws (Lederman, 2013, p.140).

Some may argue that NOS concepts are too complex for young students to understand. However, Quigley, Pongsanon, and Akerson (2010) demonstrate that when NOS concepts are taught in an informal learning environment, using explicit-reflective instruction, student understanding is improved. The researchers conducted a six-week qualitative study, which analyzed if explicit-reflective instruction improved elementary-aged (grades K-2) students' understanding of the NOS through participation in the Saturday Science class that focused on six NOS concepts: 1) science is based on observations and inferences, 2) science is empirically-based, 3) science is culturally-based, 4) science is tentative but reliable, 5) science is subjective, and 6) science is a creative endeavor. These six concepts were chosen because the National Science Teachers Association suggests that young students should have an understanding of those six NOS concepts. In their study, the researchers used inquiry-based and explicit-reflective instruction in order to present these NOS concepts to the participants. The researchers' pre-survey revealed that half of the students realized that science is a process, believed that we learn about the world through experiments, and they knew that scientists observe and make inferences. However, half of those students could not understand how scientists could be creative, only one student in second grade believed that science could change whenever new evidence was found, and none of the students seemed to understand the subjective and cultural concepts related to the NOS. Once the participants completed the course, the post-survey revealed that there was still confusion regarding the differences between observation and inference, but overall there was improvement in the students' understanding of the tentative, creative, subjectivity, social, and cultural aspects of the NOS.

In order for students to successfully understand NOS concepts, they must be exposed to the information in a way that they can understand. Therefore, Kapucu, Çakmakçı, and Aydoğdu (2015) conducted a study, over the course of six weeks, involving 113 eighth grade students taught by two different teachers in two seperate schools. One teacher taught their students aspects of the NOS through the use of showing documentaries, whereas the other teacher taught their students the aspects of the NOS the traditional way, such as taking notes and answering questions. In order to collect data the researchers used The Views of the Nature of Science Level questionnaire, which was provided to each participant as a pre-assessment and post-assessment. Both classes were taught five NOS aspects: 1) Scientific knowledge is subject to change, 2) scientific knowledge is empirically-based, 3) scientific knowledge is subjective, 4) human imagination and creativity play an important role in the production of scientific knowledge, and 5) observations and inferences are different in the production of scientific knowledge. It was found that the students who were taught the NOS concepts through the use of documentaries improved their understanding of four out of five of the concepts, whereas the students taught using traditional methods showed no improvements in their understanding of the five NOS concepts. With the use of technology, one teacher was able to present the NOS concepts in a more authentic way, resulting in a deeper level of understanding.

Students currently in K-12 classrooms have never known a world without technology, therefore, classrooms should not be an exception to that. Technology can play a vital role in bettering students' understanding of the NOS concepts (Akcay & Akcay, 2015; Kapucu et al., 2015). Akcay and Akcay (2015) examined the correlation between technology incorporated in instruction and students' understanding of the NOS and their attitudes towards science. The participants of this study included eight secondary lead teachers and their 365 students; they were involved in a summer program at the University of Iowa (Iowa Chautauqua Program). Each teacher taught two sections of science: one class served as the experimental group in which teachers implemented science-technology-society instruction (STS), and the other class lacked the implementation of STS instruction and served as the control group. A pre-assessment was given to all students prior to receiving science instruction and a post-assessment was administered following the students' participation in the science class. The results of the post-assessment revealed that students taught with the implementation of STS had a better understanding of the NOS and their attitudes towards science significantly improved in comparison to their peers who received science instruction that lacked the integration of technology.

In order for teachers to successfully teach NOS concepts to students, they must first have an understanding of those concepts themselves. Therefore, Çıbık (2016) examined the change in preservice teachers' views of the NOS after their participation in Project-Based History and Nature of Science training, using a pre- and post-assessment.The mixed method study took place in Turkey and it involved two groups of preservice teachers preparing to teach third grade attending a science teacher preperation program. Both groups were chosen at random, one group served as the experimental group and the other was considered the control group. The experimental group received project-based learning instruction and the control group received a conventional method. Overall, both the control and the experimental group had similar scores and opinions on the pre-assessment. According to the post-assessment, the experimental group showed a positive change in their views of the NOS and majority of their pre-existing fallacies were diminished as a result of their participation in project-based learning.

For students to successfully learn and develop an understanding of NOS concepts, the educator must first be knowledgeable of the concepts that they are expected to teach. Through the use of effective instruction that could involve inquiry, hands-on experiences, and technology students have the capability to learn and understand these concepts.

Inquiry-Based Learning

Students and adults alike are naturally curious. Every day, whether you realize it or not, we are constantly questioning and discovering many aspects of our natural world. For example, Google is the top engine search on the internet and whenever people have a question and seek an answer to that question they can simply type their question into a Google search and begin to delve through the results that the search engine provides. Similarly, inquiry-based learning is a type of learning that allows students to build upon their curiosity and questioning by providing students with hands-on experiences that allow them to discover and learn new concepts. However, students are not practicing inquiry whenever they are told how to conduct an experiment step by step and use a list of set procedures and rules. Within inquiry-based learning, students drive their own learning experiences through their discoveries while the educator serves as a guide or facilitator throughout the learning process. The educator can use their students' questioning and interests in order to foster many inquiry-based activities. Inquiry-based learning provides students with an authentic and meaningful way of learning through their discoveries. Much of the literature found on inquiry-based learning explains how this type of learning is beneficial to students, if educators are able to facilitate this type of learning in an effective way.

Science is “dependable knowledge that helps us understand the world in which we live” (Bybee, 2002, p. 26). However, science inquiry is much more than just a body of knowledge. Science inquiry is discoveries through observations and experiments in order to build upon scientific knowledge. Bybee (2002) explains that,

> classroom inquiry has five essential features as described in *Inquiry and the National Science Education Standards* (NRC 2000). Those features are summarized as follows: 1) Learners ENGAGE in scientifically oriented questions. 2) Learners give priority to EVIDENCE in responding to questions. 3) Learners formulate EXPLANATIONS from evidence. 4) Learners connect to scientific KNOWLEDGE. 5) Learners COMMUNICATE and JUSTIFY explanations. (Bybee, 2002, pg. 34)

Through traditional methods, educators teach their students a systematic way to “do” science, such as using the scientific method. Unfortunately, traditional methods inevitably program students to think that there is only one step-by-step way to do science, Of course, the steps of the scientific method are usually followed by scientists in order to make new discoveries or build upon scientific knowledge, but it does not necessarily need to occur in any certain order of steps.

Through inquiry-based instruction, students develop a deeper understanding of science content. One study that was conducted by Adbi (2014) looked at the differences in achievement on a pre- and post-assessment between two groups of fifth grade students (40 students total) in two science classes, one group receiving inquiry-based instruction and one group receiving a traditional method of instruction. While both groups of students were learning from the same handouts and textbooks, the inquiry-based class participated in various hands-on activities relating to the concepts taught, whereas the traditional class learned through taking notes and answering questions. The results of the post-assessment revealed that the students exposed to the inquiry-based learning method outperformed the students receiving a traditional method.

Therefore, it was shown that the students that received inquiry-based instruction developed a deeper understanding of the science concepts presented.

McCright (2012) also investigated whether inquiry-based instruction improved students' understanding of new concepts. The participants in his study included juniors and seniors at Michigan State University. These students involved in the study were previously introduced to various introductory STEM courses and McCright wanted to see if their participation in a semester-long, inquiry-based project would benefit the students' understanding of climate change in any way. The researcher collected data by administering a pre- and post-assessment. "The pretest and posttest surveys contained groups of items measuring perceptions of scientific principles, attitudes toward the social sciences and statistics, self-assessment of scientific and statistical skills, and assessed knowledge of scientific and statistical processes" (McCright, 2012, p. 89). After twelve weeks of participating in the inquiry-based project, the post assessment showed that the students understanding, attitudes, and skills of the new science concepts greatly improved in comparison to the students in other courses that did not participate in an inquiry-based project.

Schools in the United States are filled with students who are linguistically and culturally diverse. One may argue that learning new scientific concepts can be extremely difficult for these students due to their diverse learning needs and this may be true whenever these students are exposed to a traditional method of learning science. However, when provided with inquiry-based instruction, rather than a traditional method of instruction, it has been shown to be beneficial to linguistically and culturally diverse students. Lambert (2008) examined linguistically and culturally diverse students' conceptual understanding of Earth science before and after an inquiry-based science unit at five schools throughout a school district. The results of the pre- and post-assessments and questionnaire displayed significant improvements in the students' understanding across the five schools and 92% of students expressed in their responses to the questionnaire that their understanding of Earth science greatly benefited from their participation in inquiry-based instruction.

Students greatly benefit from being exposed to inquiry-based instruction, but in order for inquiry-based instruction to be successful, teachers must have the proper knowledge and tools in order to implement the learning style effectively. Flick (2000) analyzed the inquiry-based instruction provided by two veteran teachers with their use of cognitive scaffolding. In order to participate in inquiry-based learning, students must be able to think critically. However, in many classrooms students usually do not have the time, focus, or cues in order to use critical thinking skills. Therefore, cognitive scaffolding needs to happen in order for teachers to help students think critically to solve a problem. Flick followed a "critical case" sampling process because the two participants were known to practice inquiry teaching. The teachers were observed six times over six weeks with video recordings of their lessons. It was found that both teachers were active in creating scaffolds for instruction that supported learning in science; this allowed students to do what they would otherwise be able to do if unaided.

Another way that educators can successfully incorporate scientific inquiry into their classrooms is through the use of the learning cycle. The learning cycle "moves children through a scientific investigation by encouraging them first to explore materials, then construct a concept, and finally apply or extend the concept to other situations" (Marek, 2008, p. 63). Both educators and students have responsibilities throughout the learning cycle. Educators should prepare for the students' explorations with learning materials, provide students with the procedures in order to conduct the hands-on activities with the learning materials, guide the students through their exploration, and ensure that they are recording sufficient data. Whereas students' responsibilities during the process includes collecting data during their discoveries, answering questions, and assimilating data (Marek, 2008, p. 64). Once those steps of the learning cycle are completed, it is important that the teacher engage students in a discussion focusing on what processes they followed throughout their discoveries and what new concepts they have learned. After discussing the new concepts learned, educators should encourage students to apply their newfound scientific knowledge to other situations, whether it be through other experiments or in informal settings.

Similarly, Gengarelly and Abrams (2008) examined the role of scientists, teachers, and school culture through the implementation of inquiry-based learning within classrooms. Additionally, researchers analyzed the scientists' thoughts and beliefs regarding inquiry in the classroom in comparison to their own research. A qualitative study was completed over a two-year time frame. It was found that overall, classrooms began to adopt inquiry-based instruction and it was through collaboration between the scientists and the teachers.

Collaboration with other professionals is crucial for teachers to successfully implement inquiry-based instruction into their classroom. One way that teachers are able to collaborate with other professionals is through the use of professional development. Hence, Duran, Ballore-Duran, Haney, and Beltyukova (2009) completed a mixed-method study to look at the impact that a professional development program, ASTER III, had on teachers' self-efficacy and beliefs about inquiry-based science teaching. The participants in the study included 26 early childhood (K-3) teachers from public and private schools in Ohio; these participants previously participated in the ASTER I and ASTER II professional development programs. Results of participating in the ASTER III program revealed that all participants agreed that inquiry-based learning involves hands-on experiences, increases students' excitement in regards to science, allows students to be more involved in their own learning experience, and is challenging for students. Almost all of the participants agreed that inquiry-based learning allows students to find enjoyment in science content, builds upon prior knowledge, helps develop cooperative learning skills, helps retain knowledge, and includes higher-order thinking skills.

Through the research, it is found that inquiry-based instruction greatly benefits students' understanding of new science concepts through the use of discovery and hands-on learning experiences. Unlike traditional learning experiences where students are simply taking notes and answering questions, inquiry-based instruction is more meaningful and authentic, which sparks students' interests in the new concepts that their are learning. In order for inquiry-based learning to become successful in formal or informal settings, teachers must be trained on how to implement this style of instruction; one way that teachers can learn about ways in which they can implement inquiry-based instruction is through collaboration with other professionals such as scientists, other teachers, or administrators and through the use of professional development.

Summary

The literature supports that students are able to successfully learn in informal and inquiry-based learning environments, such as zoos and museums. Not only are students able to successfully learn in informal and inquiry-based settings, but these learning settings provide students with authentic and hands-on learning experiences within the real-world that students may be unable to experience in a classroom. These authentic and hands-on learning experiences often lead to a deeper understanding and retention of new science concepts through students' discovery. Students are also able to experience NOS concepts, first-hand, through their informal learning. However, educators must realize the importance and benefits of learning outside of the classroom setting and must also receive the proper training, such as professional development, in order to successfully use opportunities provided by field trips in order to create meaningful learning experiences instead of simply leisure experiences.

CHAPTER 3. MATERIALS AND METHODS

Introduction

Although there is extensive research that focuses on science instruction presented in formal settings, or classrooms, there is limited research that focuses on science instruction found in informal settings, such as museums and zoos. This study aims to look further into science content presented in informal settings, specifically how informal science instruction complements classroom instruction, how informal educators implement inquiry within their science programming, and the images of science portrayed in informal settings. Accordingly, the following research questions were addressed: 1) How does informal educators' science programming complement classroom instruction? 2) How do informal educators incorporate science inquiry in their science programming? 3) What images of science do informal educators hope to portray to students? The design of this study is qualitative in nature.

Sample

Through the process of looking at the websites of various zoos and museums in south Louisiana, the researcher found contact information for education facilitators at various informal sites. The participants were contacted directly by the researcher and were not compensated for their time or responses. The final participant pool for this study consisted of a convenience sample of four informal educators at zoos and museums in south Louisiana. The sample consisted of four females, all of whom served as informal science educators in settings such as museums and zoos. See Table 1 for participant descriptions, including their informal education context.

Table 1. Participant Summary

Participant	Role	Site Type	Description
Tracy	Outreach Coordinator	Science Museum	The science museum is located on the campus of a research-intensive university in South Louisiana. This particular museum focuses on habitats and various animal life cycles; the exhibits cater to all ages.
Misty	Retired Teacher; Informal Educator	Art & Science Museum	The arts and science museum is located in South Louisiana. This museum has various permanent and changing exhibits, as well as a planetarium; it best accommodates ages ranging from 4-18.
Sarah	Informal Educator	Children's Museum	The children's museum is located in South Louisiana and allows students to learn through play. This particular museum caters to ages 1-8.
Leslie	Youth Development Coordinator	Zoo	The zoo is located in South Louisiana . The youth programming at the zoo is catered towards ages 12-18.

Data Collection

Three types of data were collected for this research project: interviews with informal science educators, observations of site web pages, and documents of instructional materials offered by the informal learning site. Semi-structured interviews were scheduled and conducted face-to-face or through a phone interview. Each interview was audio recorded for later transcription. The interview questions were created by the researcher and were influenced by scholarly literature on informal science education and inquiry instruction as well as the informal settings' online websites and instructional materials. See Appendix B for the interview protocol.

To supplement participants' responses to questions about their site's science programming, including connections to standards and use of inquiry instruction, the researcher conducted a close analysis of each site's website. Specifically, the researcher looked for information that would assist a teacher looking to complement her classroom instruction with a visit to the informal education site. This included a listing of upcoming events, instructions on how to book a field trip, explanations of which grades events or exhibitions are best suited for, connections to standards, instructional materials for use of field trips or in classrooms, and references to science inquiry. See Appendix C for the observation protocol for the informal sites' website analysis.

Finally, for those sites which included instructional activities for use at the informal setting or in classrooms, the researcher gathered a sampling of three activities to look for emerging themes across the instructional materials offered. See Appendix D for three example activities.

Using triangulation, the researcher was able to collect data from three different sources, ensuring the validity of the data collected. These sources included the phone and face-to-face interviews, website observations, and analysis of instruction materials. Triangulation is " one of the most common methods to enhance the trustworthiness of qualitative action research studies" (Efron et. al., 2013, pg. 70).

Procedures

Prior to starting this study, the researcher sought approval from the university's Institutional Review Board (IRB); however, the interview-based research in this study did not require explicit approval from IRB (see Appendix A). The researcher did an online search for science museums and zoos in South Louisiana to develop a list of possible locations and identify potential participants (i.e., education/science education curators at each site). Additionally, the researcher searched each informal location's website for an overall impression of the informal setting as well as for teacher instructional materials. Participants received an overview of the research through email and signed a consent document for good measure, though not required by the university. With the participants' permission, interviews were audio recorded for later transcription. Interviews lasted an average of approximately 11 minutes (range: 8 minutes minimum;15 minutes maximum) and were transcribed individually verbatim without the use of assistive software. See Figure 1 for a timeline of these procedures.

Data Analysis

For my research, I decided to analyze my data using structural coding (Saldaña, 2013). I chose to use structural coding because "it is appropriate for virtually all qualitative studies, but particularly for those employing multiple participants, standardized or semi-structured data-gathering protocols, hypothesis testing, or exploratory investigations to gather topics lists or indexes of major categories or themes" (Saldaña, 2013, p. 98). Using *The Coding Manual For Qualitative Researchers* (2013), I focused on each interview question, one at a time, and analyzed each participant's responses. Utilizing the Interview Summary table (see Appendix E), I documented relevant words and phrases that were found in the participants' responses to my interview questions. Once I had all of the participants' responses to my interview questions placed in the Interview Summary table, I was able to clearly see common themes and unique responses throughout each informal educators' views of science, science inquiry, and the NOS.

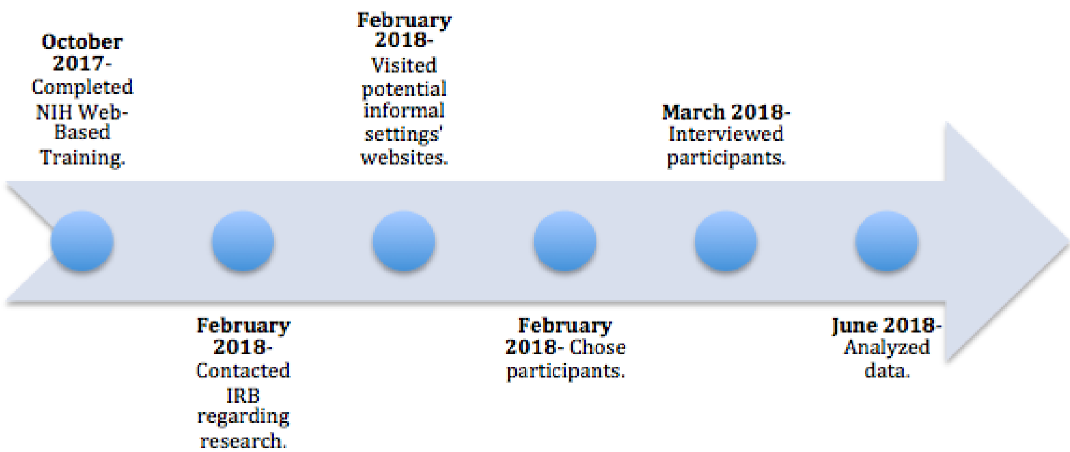

Figure 1. Timeline of Procedures

Additionally, I analyzed each informal setting's website using an observational criteria table (See Appendix C) and three instructional materials found on one of the websites using open coding. As I was looking through each website, I used the table to mark whether the website included certain resources, such as:

1. Upcoming events
2. Instructions on how to book a field trip
3. Explains which events cater to which grades
4. Includes Common Core Standards or NGSS
5. List of various exhibits

6. Provides instructional materials for field trips
7. Include language referring to scientific inquiry

Through looking at the observation protocol and analyzing the results, I was able to see which informal settings possessed which resources for educators on their websites.

Limitations

My research consisted of looking at whether informal settings' science programs complemented classroom instruction, how informal educators incorporated science inquiry into their science programs, and what image of science the informal educators hoped to portray within their science programs. However, because I only gathered data from four informal settings in South Louisiana, my findings may not apply to informal settings in other areas of the state, country, or world.

Challenges that the researcher faced throughout the study included a small sample size (Merriam, 2001) and longitudinal effects (Senunyeme, 2012). Due to the small sample size and the limited amount of time allotted to complete the research study, the researcher received a limited amount of data regarding the research topic. The small sample size affects transferability of findings to other contexts, and longitudinal effects limit opportunities for the researcher to explore how site's science programming might change, especially in light of the new Louisiana Student Standards for Science.

Summary

There is an abundant amount of research available with a focus on science instruction presented in formal settings, such as classrooms. However, the researcher was interested in research that focused on science instruction presented in informal settings, such as zoos and museums. Therefore, the researcher began an online search for informal science museums and zoos in South Louisiana and was able to find six informal science locations. As the researcher searched through each site's website, the potential informal educators were identified and contacted; four of the six potential participants were responsive to the researcher.

The researcher developed a set of interview questions from the researcher's interest and her reading of the literature. The participants were presented with a consent form informing them about the purpose of the study. Once the consent form was signed, the interview was conducted. In addition, the researcher completed observations of the informal settings' websites and she also analyzed the instructional materials that the websites provided. Findings from the data are discussed in the following chapter.

CHAPTER 4. FINDINGS

As a formal elementary educator, the researcher was interested in looking further into science instruction in informal settings, such as museums and zoos. The findings discussed in this section represent an overview of four informal science learning sites, including four informal educators' interview responses, a review of the sites' websites, and an analysis of the instructional activities provided online by one informal learning setting. Throughout their responses to the interviews, participants discussed how they feel science is portrayed in their museum or zoo, how their programming can help students to better understand science concepts, and how their programming can help students to better understand the NOS. I present findings from the interviews and then discuss the websites and instructional activities provided by the informal learning settings. See Appendix E for an Interview Summary table.

Participant Interviews

Field trip logistics. Since museums and zoos are popular field trip options for formal educators, like myself, I was interested in finding out what age group each informal setting was catered towards, if their science program aligned with the Common Core Standards or Next Generation Science Standards (NGSS), and what process a formal educator would have to go through in order to book a field trip with the museums or zoo involved in my study. Therefore, once asked these questions, all informal educators were able to provide me with an age range and if their program aligned with any standards. However, three of the four informal educators were able to provide me with a process for scheduling, planning, or taking field trips. For example, Tracy stated that the science museum could be catered to all ages, "everyone from families to, like, seniors who are retired and they are just looking for something to do" (Tracy, personal communication, March 7, 2018) except for on Saturdays, because on Saturdays they "have a kid’s program called Special Saturdays, that’s ages 5 to 12” (Tracy, personal communication, March 7, 2018). When questioned if her science program aligned with the Common Core Standards or NGSS, Tracy said, “it’s outdated so it’s not Common Core or um, the new stuff, but we do have activities on our website that has when it used to be GLEs [Grade Level Expectations], I guess it doesn’t apply anymore but they are listed on the website. So I should probably go in and update (Tracy, personal communication, March 7, 2018). In order for formal educators to book a field trip with the science museum, they have three different options; Tracy explained that teachers can either “call me at the office number, they can email the museum, or we have a form online that you could fill out and it is just a field trip request form” (Tracy, personal communication, March 7, 2018). The science museum seemed to be very accommodating in providing guests with many different options in order to contact them regarding visits. On the contrary, when Misty was asked about the process educators would have to go through in order to book a field trip to the arts and science museum, she did not provide a clear process. Instead, she stated,

> We have online lessons teachers can look at and use and adapt in the classroom or some teachers don’t do anything they just bring the students because the topic we are teaching here is close to the topic they are teaching in the classroom. We have materials here to do the hands-on and the space here to do it. We, uh, do not give any tests. We do not give any assessments so the students feel like they are a little more at ease. (Misty, personal communication, March 10, 2018)

However, she was able to provide me with a specific age range for the arts and science museum by stating,“Well, we have classes for K-8” (Misty, personal communication, March 10, 2018), and she said that they are trying to “align our program with the new national NGSS” (Misty, personal communication, March 10, 2018). Moreover, at the children’s museum, Sarah mentioned that the program caters towards ages “1-8, my area in particular is for ages 4-8” (Sarah, personal communication, March 15, 2018) and she mentioned that in order for formal educators to book field trips they must “submit various dates and times and we try our best to accommodate the first time and date that they pick” (Sarah, personal communication, March 15, 2018). When asked if the children’s museum’s programming was aligned with the Common Core Standards or NGSS, Sarah was unsure. She stated,

> Yeah, I’m not sure. I know that we align our activities with Louisiana state standards.So we have an early childhood education specialist and she puts the state standards on all the stuff we turn in. Um, but i’m not sure about Common Core. I don’t think she’s looking at anything other than the state standards at this point (Sarah, personal communication, March 15, 2018).

Additionally, Leslie stated that her youth program, in particular, is catered towards ages “12 to 18. Um, but out at the zoo we get a lot of very young children in that informal education range and in our school programs it is kind of elementary education, is most of the range that we get” (Leslie, personal communication, March 16, 2018). She added that the school programs are aligned with the Common Core Standards and NGSS by stating, “school programs definitely do. Um, they are kind of built around that” (Leslie, personal communication, March 16, 2018). However, she mentioned that her youth program is

> slightly different in that, um, so that kids aren’t coming, you know teachers usually are taking these field trips and they have to justify it so um, i’m hitting a lot of those, um, i’ve read them and i’m like, yeah I do a lot of those. It just kind of changes the way, you know, I don’t really have to do them in that kind of order. Um, and a lot of times I get feedback from parents and the kids themselves, they’re like, oh yeah when I went to school this next year this came up and i’m like oh here I know all of this already. Um, so I think it is connecting, but not in the formal way that the school programs do. (Leslie, personal communication, March 16, 2018)

So even though Leslie’s youth program at the zoo is not specifically aligned with the standards like the school programs are, she says that she still covers those standards within her informal instruction. She also explained that in order for formal educators to book a field trip at the zoo, they can find information online and

> then they usually have to call our reservations, there's a special group reservations, um, coordinator and she then talks to the school program coordinator. And so then the school program coordinator looks at her schedule to see what, you know, if that is an available time and from there they book the formal space in the zoo. Um, she works with the teacher to figure out what specifically they want their class to focus on. (Leslie, March 16, 2018)

Therefore, all informal settings seemed welcoming of students coming from school settings in order to visit their museum or zoo, and two of the participants stated that they specifically work with formal educators in order to make sure that the instruction that is taught at the museum or zoo would align with classroom science instruction.

Meanings of science. When asked what science meant to the participants, three participants spoke similarly about discovering and understanding new concepts and also mentioned that science is always changing. For example, Tracy stated that science is, "just being curious about the world and how it works and exploring and trying to, yeah I guess just figuring out life" (Tracy, personal communication, March 7, 2018). Misty added, "Science itself is a constantly changing environment. It's uh always looking for new ways to do things. It's always looking for something that can stimulate, as a teacher, could stimulate children's thinking of new ways and it is always thinking outside of the box" (Misty, personal communication, March 10, 2018). Additionally, Sarah stated, "science to me is, um, applying concepts that we don't quite understand and making them relevant to us." (Sarah, personal communication, March 15, 2018).

On the contrary, one participant explained what science meant to her by discussing a stereotypical image of science and scientists: in a laboratory, wearing a white lab coat. She explained, "I think a lot of people, myself included, think of scientists as people in white lab coats in a laboratory and those are the only scientists. Um, and we tend to, you know, not think of everyday people as scientists" (Leslie, personal communication, March 16, 2018). Additionally, Leslie mentioned that she felt very uncomfortable calling herself a scientist due to the fact that she does not work in a laboratory. For example, she said, “Um, but you know, since I don’t, um, work in a lab I don’t consider myself a scientist” (Leslie, personal communication, March 16, 2018).

Images of science. Unlike defining what science is, all participants had varying responses when they were questioned about how science is displayed in their zoo or museum. Tracy spoke mainly of the animals and exhibits that were displayed in her science museum. She stated, “we have animals and exhibits about animals so it is mostly portrayed with those types of topics” (Tracy, personal communication, March 7, 2018). Misty, on the other hand, discussed several different ways that science was displayed in the arts and science museum,

> Children come here and take classes for one and half hours on all sorts of topics from bridge building, to creating electric circuits, to talking about butterflies. So, uh, the museum has opportunities, structured opportunities, for field trips and then there are a lot of weekend activities for, uh, children to come to with their families, plus, their are rotating exhibits. (Misty, personal communication, March 10, 2018)

Through the many hands-on activities that students experience in the arts and science museum, Misty felt that it exposed them to various science concepts in an authentic way. Furthermore, Sarah also mentioned hands-on projects that guests participate in at the children's museum. She discussed one building activity in particular in which students are prompted to build a house out of PVC pipes. She stated, “So like our area that is, um, kind of a construction zone is all like engineering, physical science, but it’s like you know, let’s build a house out of these PVC pipes” (Sarah, personal communication, March 15, 2018). Whereas, in the youth program at the zoo, Leslie mentioned that her students experience science by interacting and educating the guests throughout the zoo. For example, “like explaining how cold blooded animals work or um, you know, like how a rabbit with long ears, they’re pushing blood into their ears to cool off. It’s kind of like when we sweat” (Leslie, personal communication, March 16, 2018). Leslie stated that the students in her youth program greatly benefit from interacting with individuals in the community and enjoy helping the guests understand many traits and features of the animals within the zoo.

Special features of the informal learning settings. Since participants were from four different informal settings, the researcher was interested in what each informal educator thought made their museum or zoo stand out from other museums and zoos in Louisiana. Each participant's response included certain activities and exhibits specific to their museum or zoo. Tracy explained that her museum has a "cool factor" that sets it apart from others. She stated, "Well, we have a really, a cool factor… so if kids come in and see the type of work that we do they are normally pretty excited about it and, um, our scientists travel all over the world in remote places so they have a lot of great stories of those kinds of expeditions and discovering new species" (Tracy, personal communication, March 7, 2018). Misty explained that she was not familiar with other museums in the area but explained why she thought the arts and science museum stood out from others by stating,

> Here it seems to be changing and more dynamic than some of the other museums. We have more to offer, from anything, anywhere to comparing your height to a polar bear's height, actual size, to uh, doing some more, um, more sophisticated activities in our classrooms. We have uh, this museum also has a program for girls interested in science from deprived areas. (Misty, personal communication, March 10, 2018)

Sarah mentioned the children museum's "maker space" area several times throughout our interview and she felt that it was one of the things that her museum had that really made it stand out from other museums in Louisiana. For example, she stated,

> I think we have one of the only maker's spaces in a museum in Louisiana. I don't think there are other ones. At least, not at the level that we have it or maybe with the projects and programs that we lead. So, um, we have something that's more than just like looking at, um, some scientific objects and learning about it. We have them actually building, making, constructing, taking things down, taking things apart. So it's more of learning through doing, I guess more of kinesthetic

> learning, than just verbal or visual. (Sarah, personal communication, March 15, 2018)

Similarly to Sarah, Leslie also mentioned a hands-on aspect at the zoo that she felt made her youth program stand out from other zoos in the area. She stated,

> I think it is definitely that hands-on aspect. These kids get to do things that many people in their entire lives never get to do, um, it is not a very common thing, even among zoos, for volunteers to be able to be this involved with housentry and education and all of that. So I think it's that and we also do developments. So it's not just like hey come volunteer with us. We have education days, we take field trips. I am about to take the group to Dauphin Island, Alabama for the weekend and go to the sea lab. (Leslie, personal communication, March 16, 2018)

Science content. Furthermore, when questioned about what science concepts they hoped that students learned from their particular zoo or museum and if they thought their science programming bettered students' understanding of those concepts, two of the participants seemed to need further explanation as to what "science concepts" were. For example, one participant responded, "Science concepts? So, give me an example" (Tracy, personal communication, March 7, 2018). Once the question was explained further she stated, "if you don't have someone to point those things out it might be difficult especially for younger kids" (Tracy, personal communication, March 7, 2018). Due to her responses to the question, the researcher inferred that this informal educator may not have a clear understanding of what science concepts are, even after a further explanation. Another participant also questioned what science concepts were when first asked, but then she was able to answer the question without further explanation. She stated,

> Science concepts? Umm, I think most of what we do is physical science based or, um, maybe a little of earth science, but just to kind of understand the concept of whatever we've got going on in there. So it changes, it changes every month, but for some of the stuff that's actually permanent in the museum that's science based, i'd say, you know, things like gravity and what would happen if you built this and then you took this part of it? Would it fall down? Why would it fall

> down? Um, like structural type things. (Sarah, personal communication, March 15, 2018)

Although Sarah questioned what science concepts were at first, she was eventually able to give examples of concepts taught in the children's museum. Then when asked if she thought her science programming was able to better the students' understanding of those science concepts she said,

> I think that any time that the student is able to put their hands on it and actually, like, you know, play with it, take it apart and understand how the thing works. That's a learning, um, it sticks with them, I think, a little bit better than in some cases where they were just reading about it or watching a video about it. They are actually using more of their senses. (Sarah, personal communication, March 15, 2018)

The remaining two participants were able to provide a response to what science concepts they hoped students learned and if they thought their science programming bettered students' understanding of those concepts without hesitation. For example, Misty replied,

> Well, in all of our classes we have different types, we have uh, biological like I said, we have forensic science and that takes on a lot of the different science disciplines. Uh, we have a lot of physical science, um, creating circuits and studying light. Um, studying um, like I said, engineering, like the bridge building. Um, the uh, we have two different circuit ones; one is using lemons to create batteries. So like I said, we have a lot of different topics. (Misty, personal communication, March 10, 2018)

She added that "through the hands-on [activities]" (Misty, personal communication, March 10, 2018) students are able to better understand those science concepts. Moreover, Leslie explained that once students have participated in her youth program at the zoo she hopes,

> that they get an idea that for the basis of things that things are all connected. That it is not just about, you know, this one animal or this one topic. That everything is connected and circles back and that we are a part of that, we are not separate from it, we are a part of that. And um, i'm hoping they can see those connections better, um, and no matter what they do in their lives I hope they can bring those connections with them. So even if they end up in like the corporate world they can still look for ways to minimize their impact, their negative impact on those things (Leslie, personal communication, March 16, 2018).

Leslie stated that she thinks she has more flexibility and can be more creative in bettering students' understanding of the science concepts presented in the zoo. For example, she said,

> I think I have a little more flexibility in addressing them. Um, I am not having to teach to any kind of testing. I'm not, you know, sometimes teachers kind of get boxed in. So I have a little bit more flexibility in the ways I can teach, um, I can do more active learning, um, because they are coming to me specifically in the summer or that kind of thing. Um, and so I think that, um, you know, you can get a little bit more creative. You can take the time to, if one person is particularly really interested in something or didn't quite grasp something I can kind of take the time and make it work for them or try to find them further resources of something they are really interested in. (Leslie, personal communication, March 16, 2018)

Nature of science. In a similar way, when the participants were questioned about what aspects of the nature of science were incorporated into their museum's or zoo's science programming, the same two participants who did not seem to have a clear understanding of what science concepts were also seemed to lack understanding of the nature of science. For example, when speaking to Tracy, she seemed to not understand what I meant by "nature of science"; therefore, I had to explain to her what the nature of science was and then she replied, "So if you are just looking at the exhibits, it really doesn't, because our exhibit style is more of the traditional way of doing things, which is here is a habitat scene, take what you want from it" (Tracy, personal communication, March 7, 2018). Tracy believed that her science museum exhibits did not include aspects of the nature of science. Then, when I questioned Sarah regarding the nature of science her response was, " Oh, we try to include all sciences" (Sarah, personal communication, March 15, 2018), not seeming to understand the meaning of the nature of science through her response.

However, the two remaining participants seemed to have a grasp on what I was asking them in regards to the nature of science. Misty mentioned,

> it's all hands-on and it's all discovery. We present a challenge to the students and we give them a little bit of the information and then they are to build on that information. Usually, they have to create something. Even the prek kids make an ant to show the three parts of the insect's body and then we do art prints of butterfly's wings to show bilateral symmetry. (Misty, personal communication, (March 10, 2018)

Leslie spoke about how making sure the students understand how science works throughout her youth program is a priority. She stated,

> So in youth programs, especially which it comes to climate change, I really try to make sure they understand how science works. Um, because you hear a lot of misinformation about climate change especially, so people are like oh well those 97% of scientists are being paid to say something, or something along those lines. Like, that's not how science works, and explain the difference between a theory and a hypothesis.When you say something is a scientific theory, you're really saying we are pretty darn sure. Um, so things like that, um, I know with our school programs it is part of meeting the standards, the school standards. And I know with the new standards there's a big emphasis on the science aspect. So they is more of a focus on hypothesis, testing, those types of things. Um but definitely I think our programs are trying to get them to understand. (Leslie, personal communication, March 16, 2018)

Websites of Informal Settings

Each informal learning site provides a website for potential guests that includes information about their museum or zoo. These websites can be particularly helpful to formal educators as they are trying to decide where to take their students on a field trip. However, the amount of information that is provided by these websites varies some of the websites include a lot of resources, whereas some of the websites include very little. Therefore, the researcher created a Website Observation chart (see Table 3) in order to keep track the resources that each website included for their guests. Within the chart the researcher created a list of criteria for observation of the websites: includes upcoming events, provides instructions on how to book a field trip, provides explanations of which events cater to which grades, includes Common Core Standards or NGSS, provides a list of various exhibits, provides instructional material for field trips, and includes language referring to science inquiry. Through the completion of the website observation it was found that the websites of all four informal settings included upcoming events, instructions on how to book a field trip, a list of various exhibits, and language referring to scientific inquiry. Three out of four of the websites explained which events catered to which grade level, one out of the four included reference to Common Core Standards or NGSS, and one out of the four provided instructional materials for field trips.

Activities from Informal Settings

Out of the four informal settings at which participants worked, although they all had websites, only one website included activities for educators to access for their students. See Appendix D for three examples of activities. Through analyzing three activities provided by the science museum's website, the researcher found three major themes across the activities. The first theme that the researcher noticed was that a student would not necessarily have to be at the science museum in order to complete the activities; the activities were not integrated with exhibition or science programing. For example, all three of the activities analyzed included some sort of game such as a coloring activity, a matching activity, a crossword puzzle, and a word search; these activities would be able to be completed in any setting and did not require the student to be at the museum. Additionally, the researcher noticed that none of the three activities were aligned with the Common Core Standards or NGSS and they did not list any GLEs. Finally, these since these activities included games, such as crossword puzzles and word searches, they were not inquiry based in order to aid or supplement classroom instruction.

Table 3. Website Observation

Website Observation Criteria	**Art & Science Museum**	**Science Museum**	**Children's Museum**	**Zoo**
Upcoming Events	✓	✓	✓	✓
Instructions on How to Book a Field Trip	✓	✓	✓	✓
Explains Which Events Cater to Which Grades	✓	x	✓	✓
Includes Common Core Standards or NGSS	x	x	x	✓
List of Various Exhibits	✓	✓	✓	✓
Provides Instructional Materials for Field Trips	x	✓	x	x
Includes Language Referring to Science Inquiry	✓	✓	✓	✓

Summary

Overall, the information collected through the interviews, website observations, and activities were extremely beneficial for the researcher. The participants' responses to the interview questions provided the researcher with an insight to their views and beliefs regarding science, science inquiry, and the NOS. Furthermore, the informal settings' websites and activities displayed what resources were available to formal educators in regards to aiding or supplementing their instruction.

CHAPTER 5. CONCLUSIONS AND IMPLICATIONS

As I began my research, I thought I had a pretty clear understanding of what informal settings, the nature of science, and inquiry-based learning were due to my previous research in undergraduate and graduate school, as well as my experiences as a teacher. However, throughout this study I have gained a deeper understanding of the three topics listed above, I have become more confident, as an educator, on how to implement the nature of science and inquiry-based learning into my instruction more effectively, and I have learned how to make learning in informal settings more meaningful to students through the reading of the literature and interviews with informal educators.

Summary of the Study

The purpose of this study was to examine science instruction that is completed within informal settings, specifically analyzing instruction that incorporated the nature of science and inquiry-based learning, the informal settings' websites, and instructional material found on one of the websites. The study involved four informal educators from four informal learning settings in South Louisiana. It investigated informal educators' views and perceptions of science, science inquiry, and the nature of science and it specifically addressed whether informal educators' science programming complemented classroom instruction, ways in which informal educators incorporated science inquiry throughout their instruction, and the images of science that the informal educators hoped to portray within their museum or zoo. Data were collected for the study through interviews with the participants, observations of the informal settings' websites, and analysis of instructional material provided by the websites. Prior to conducting the interview, the participants were sent a consent form, which included an overview of the study. Once the consent forms were signed and returned to the researcher, the interviews were conducted. The interviews were analyzed through structural coding, with the use of an interview summary chart, where I recorded relevant words and phrases through the participants' responses to the interview questions. The websites and instructional materials were analyzed through open coding. An observational protocol was used as a checklist of criteria for the websites. Only one website included instructional material and after analyzing three activities the following major themes emerged: 1) Students did not need to be at the museum in order to complete the activities; 2) The activities were not aligned with the Common Core standards, NGSS, and GLEs; and 3) All activities included games, such as crossword puzzles and word searches, and were not inquiry-based activities.

Research Questions

How does informal educators' science programming complement classroom instruction? The data collected throughout the study revealed that whether or not the informal educators' science programming complemented classroom instruction depended on two factors. First, it depended on whether or not the informal educator was willing to work with the formal educator. Two out of the four informal educators mentioned in their interviews that they speak to the formal educator, as the the formal educator is booking a field trip, and they ask them what topics they would like covered during their visit to the museum or zoo. In this way, the informal educators' science programming most definitely complements classroom instruction through collaboration with the formal educator.

Another factor to consider when wondering how informal educators' science programming complements classroom instruction is whether or not the formal educator is aware of how to make an informal learning experience a meaningful one, in order to avoid falling into the trap of making it simply a leisure activity (Tunnicliffe, 2007). When planning a field trip to an informal setting, formal educators must keep in mind the purpose of their visit and how it can benefit their students' learning in order for it to be a successful informal learning experience. Therefore, they must be thoughtful about where they may take their students on a field tip. For example, if the formal educator is teaching about animals and their habitats in the classroom setting, they may want to take their students to the science museum where the whole museum is dedicated to animals and their habitats or maybe to the zoo. Additionally, three out of the four informal settings' websites included descriptions of events that catered to certain grades levels and all of the websites listed various exhibits within their site; the websites serve as a great tool for formal educators. Collaboration between the formal educator and informal educator is as important as a formal educator knowing how to make a field trip a meaningful learning experience in order for the informal educators' science programming to complement classroom instruction.

How do informal educators incorporate science inquiry in their science programming? The literature has proven that it is crucial for teachers to collaborate with other professionals, such as informal educators, in order to make science inquiry successful in the classroom (Duran et. al., 2009). Therefore, the way that informal educators incorporate science inquiry within their science programming essentially effects students' understanding of science concepts in the classroom setting. Throughout the interviewing process, each informal educator provided me with unique responses as to how they incorporated science inquiry into their science programming. Overall, they all mentioned that the students are able to learn through a hands-on learning approach at their informal site. Additionally, some informal educators mentioned that the students are able to learn through challenges, building and creating. Words such as hands-on, challenges, building, and creating can also be found on the informal settings' websites.

However, it is worth noting that for the one site with instructional materials available online, these materials were not hands-on or inquiry-based. Rather, the instructional materials were worksheets (e.g., word searches, crossword puzzles) that could be completed independent of the informal education setting.

What image of science do informal educators hope to portray to students? The data collected throughout the interviews revealed that each informal educator hoped their museum or zoo portrayed varying images of science. One participant mentioned that her science museum is all about animals and their habitats and she hoped that students were able see science through her exhibits in the museum. She also mentioned that the students have the opportunity to touch and explore various specimens throughout the museum (Tracy, personal communication, March 7, 2018). Another participant mentioned that her arts and science museum displays science through challenges and building (Misty, personal communication, March 10, 2018). Similarly, it was stated that the at children's museum science is displayed through challenges, building, and also play (Sarah, personal communication, March 15, 2016). The zoo was said to display an image of science through interacting and educating guests throughout the museum, it gives the students in her youth program a hands-on learning experience throughout the zoo where they are seen as the expert (Leslie, personal communication, March 16, 2016). Hands-on learning is crucial in order to move students through science investigations (Marek, 2008). Overall, each participant mentioned that students experience science through some aspect of hands-on experiences while they are visiting their informal site.

Implications

Within an informal learning environment, students are given opportunities in a real-world environment that they otherwise would not be able to experience within the classroom setting.

The advantages for effective informal learning are beneficial for the students and can also serve as a benefit for the formal educator. Having those hands-on learning experiences can help aid or supplement classroom instruction and also the formal educator can use those informal experiences to help her explain certain concepts to students. However, teachers should be instructed on how to use these informal learning experiences during field trips in order to complement their instruction within the classroom. Furthermore, research shows that informal learning provides social and linguistic interactions in order to aid in the understanding of science content (Verma et. al., 2015).

Further Study

There are several aspects of this study that could be studied further. First, I would like to see if the results of this study would have changed, and how they would have changed, if informal settings in other parts of the state, country or world were investigated. Additionally, I believe that the study would benefit from a larger sample size; therefore, the data would not be as limited to the views and beliefs of only four participants. I also would like to see how the results would change if the study kept the same form but investigated these informal settings over a longer period of time, such as a year, to see if maybe implementation of the new Louisiana Student Standards for science would change the results of the study. I would also like to see what the data would look like if the researcher could observe field trips at each informal site. Finally, I would add other sections to the observation protocol in which the researcher would analyze the vision and mission statements of each informal website and look to see if these informal sites receive any grant funding or support.

Recommendations for Teachers

In order for field trips to become meaningful experiences that supplement or aid classroom instruction, teachers must be thoughtful in choosing which informal site they would like to take their students to. Majority of informal site's websites provide educators with events and exhibits that they offer, and additionally, the sites often provide appropriate grade levels for each of the events or exhibits. As a formal educator, you can use the websites as a great tool to insure that you are aligning your instruction to events and exhibits that the informal sites offer.

Conclusion

Going through the research process has taught me a great deal, as an educator, about the positive effects of informal learning and just how important the formal educator's role is throughout that experience. Informal learning offers students an authentic learning experience that formal educators simply cannot provide within the four walls of the classroom. These experiences aid in students' understanding of new science concepts and the nature of science by the use of investigations within a real-world setting, discovery, creating, and exploration.

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APPENDIX A. IRB APPROVAL

Subject: IRB Application
Date: Tuesday, February 27, 2018 at 11:23:36 AM Central Standard Time
From: Institutional R Board
To: Michelle E Gomez
CC: Angela W Webb

Hi,
The IRB chair reviewed your application, Science Inquiry Through Informal Settings, and determined IRB approval for this specific application (IRB# E10916) is not needed. There is no manipulation of, nor intervention with, human subjects. Should you subsequently devise a project which does involve the use of human subjects, then IRB review and approval will be needed. Please include in your recruiting statements or intro to your survey, the IRB looked at the project and determined it did not need a formal review.

You can still conduct your study. It falls under a certain category that does not need IRB approval.
Elizabeth

LSU

Elizabeth Cadarette
IRB Coordinator
Office of Research and Economic Development
Louisiana State University
131 David Boyd Hall, Baton Rouge, LA 70803
office 225-578-8692 | fax 225-578-5983
eantol1@lsu.edu | lsu.edu | www.research.lsu.edu

LSU Research - The Constant Pursuit of Discovery

APPENDIX B. INTERVIEW PROTOCOL

The researcher interviewed informal educators with the following interview questions. Each interview was audio recorded and later transcribed.

1.) What does science mean to you?
2.) How is science portrayed in your museum's/zoo's programming?
3.) What aspects of the nature of science- what science is/how it's done- are incorporated into your science programming?
4.) What age group does your program cater most towards?
5.) What is the process that teachers have to go through in order to bring students to your museum/zoo?
6.) Does your science programming offer hands-on experiences for students? If so, please describe.
7.) What does your science programming offer that can further science inquiry for students?
8.) Does your science programming provide activities that connect to the Common Core Standards and/or Next Generation Science Standards for teachers? If so, please provide examples.
9.) What do you think makes your science programming stand out from other science programming at other museums/zoos in Louisiana?
10.) What science concepts do you hope students learn from attending your museum/zoo?
11.) How do you think your science program could better students' understanding of science concepts?

12.) How do you think your science program could better students' understanding of the nature of science?

APPENDIX C. OBSERVATION PROTOCOL

The researcher reviewed each informal setting's website and looked for the following criteria:

1.) Upcoming events

2.) Instructions on how to book a field trip

3.) Explains which events cater to which grades

4.) Includes Common Core Standards or NGSS

5.) List of various exhibits

6.) Provides instructional materials for field trips

7.) Include language referring to scientific inquiry

APPENDIX D. WEBSITE ACTIVITIES

ENDANGERED SPECIES... WHAT CAN WE DO?

Link to our exhibit: "Louisiana's Past: The Border of a Canebrake"

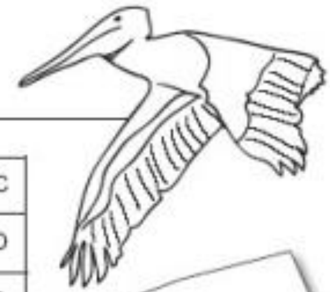
Some species are threatened or endangered. You and your school can make a difference to help conserve some of these species and their habitat. For instance, you can organize campaigns at local science events and tell the public about endangered species in general, or about a particular endangered species from your area.

To help you learn more about this subject, here are some questions about threatened or endangered species. The answers to these questions are the hidden words listed below!

1) Extinction is natural and happened before humans lived on the planet (i.e., the extinction of dinosaurs). Why is this normal process a concern now?
2) About how many species became extinct in the last century?
3) What is the natural extinction rate per hundred years?
4) What is the abbreviation for the Endangered Species Act?
5) What shellfish is in trouble in America's streams?
6) Which loss is the biggest threat for a species?
7) What is the acronym for the federal agency that protects endangered species & habitats and manages the National Wildlife Refuge System?
8) What do you call the many different kinds of life in all their forms?
9) What do you call a species that is in immediate danger of becoming extinct?
10) What do you call species that invade and crowd out a native species?
11) What do you call a species when there is no more time to save it?
12) What do you call a species that is vulnerable, but not yet in immediate danger of extinction?
13) What do you call the elected body that passes legislation such as the Endangered Species Act?
14) What is the estimated percentage of plants and animals that have gone extinct since the beginning of time?
15) What do you call plants and animals which are not listed as threatened or endangered but that are being considered as such?
16) What is the ultimate goal of the Endangered Species Act?
17) What is America's most famous recovered species?
18) What is the name of a successfully recovered species in the South?
19) What is the name of a species that is endangered in Louisiana?
20) What is the name of a species that is threatened in Louisiana?

THE HIDDEN WORDS

BALD•EAGLE
BIODIVERSITY
BLACK•BEAR
BROWN•PELICAN
CANDIDATES
CONGRESS
ENDANGERED
ESA
EXOTICS
EXTINCT
HABITAT
HIGHEST•RATE
MUSSELS
NINETY
ONE
OVER•ONE•HUNDRED
RECOVERY
RED•WOLF
THREATENED
USFWS



R	A	A	B	L	A	C	K	B	E	A	R	B	H	C
I	E	J	R	K	K	O	M	A	L	M	M	O	I	D
I	X	D	O	E	Q	E	E	L	R	S	Y	P	G	D
B	T	T	W	X	U	V	W	D	X	Y	Z	P	H	E
I	I	P	N	O	T	H	R	E	A	T	E	N	E	D
O	N	E	P	T	L	A	A	A	N	S	W	F	S	U
D	C	H	E	I	C	F	E	G	I	E	C	B	T	F
I	T	A	L	C	C	R	Y	L	Y	S	S	E	-	G
V	E	B	I	S	O	U	R	E	C	O	V	E	R	Y
E	I	I	C	O	N	G	R	E	S	S	E	T	A	T
R	U	T	A	B	R	O	W	N	N	B	E	E	T	E
S	C	A	N	D	I	D	A	T	E	S	W	R	E	N
I	U	T	M	U	S	S	E	L	S	U	E	F	E	I
T	L	E	G	R	H	H	R	E	A	J	D	J	L	N
Y	F	R	J	F	E	N	D	A	N	G	E	R	E	D
O	V	E	R	O	N	E	H	U	N	D	R	E	D	H

THE HIDDEN WORDS

BALD•EAGLE
BIODIVERSITY
BLACK•BEAR
BROWN•PELICAN
CANDIDATES
CONGRESS
ENDANGERED
ESA
EXOTICS
EXTINCT
HABITAT
HIGHEST•RATE
MUSSELS
NINETY
ONE
OVER•ONE•HUNDRED
RECOVERY
RED•WOLF
THREATENED
USFWS

The content of this section is based on material from the US FWS.

LOSS OF HABITAT AND EXTINCT SPECIES...

IS IT REALLY HAPPENING?

Link to our exhibit: "Louisiana's Past: In a virgin bottomland forest"

Unfortunately, for some species, it is too late. The loss of their habitat resulted in their extinction. Here are some facts about extinct species. Can you tell if they are true or false?

GAME 1: "TRUE OR FALSE" ON EXTINCTION.

		TRUE	FALSE
1	At least one in eight known plant species in the world is threatened with extinction.	◯	☐
2	Species are becoming extinct at a much faster rate now than in the past.	◯	☐
3	90 percent of all large fishes have disappeared from the world's oceans in the past half century, mainly because of industrial fishing.	◯	☐
4	Lions are close to extinction as their populations in Africa have fallen by almost 90% in the past 20 years.	◯	☐
5	A few species of dinosaurs survived when a meteorite hit the Earth, 65 million years ago, and transformed their habitat.	◯	☐
6	Humans continue to drive many species to extinction by destroying ecosystems and by upsetting nature's balance (by extensive development, mining, pollution, etc).	◯	☐
7	Nowadays, human-caused extinction is estimated to be taking place between 100 to 1,000 times faster than natural extinction.	◯	☐
8	Today's fast extinction rate is similar to five earlier periods of extinction, each caused by a catastrophic natural disaster. Thus, we are facing today the Earth's sixth major extinction phase.	◯	☐
9	The sixth extinction period is independent of our modern life style (pollution, industrial fishing, deforestation, etc).	◯	☐
10	Nearly one of three plant species in the United States is under threat of extinction.	◯	☐

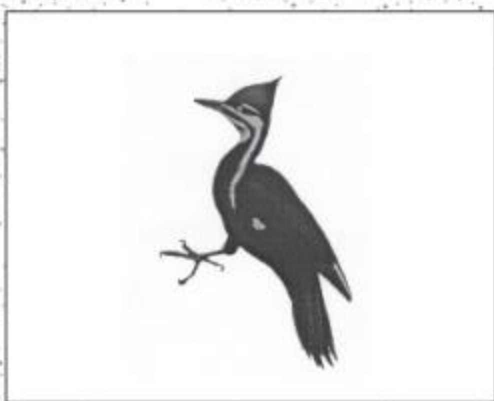
In the mid-1900s, a beautiful bird once common in Louisiana, the Ivory-billed Woodpecker, became extinct as a result of the loss of its habitat. Ornithologists have little hope now of finding surviving individuals and saving this bird.

Would you recognize the Ivory-billed woodpecker if you saw one? Here are some of the main differences between three similar looking woodpeckers.

GAME 2. CAN WE STILL SAVE THE IVORY-BILLED WOODPECKER?

SPECIES	Ivory-billed woodpecker	Pileated woodpecker	Imperial woodpecker
LATIN NAME	*Campephilus principalis*	*Dryocopus pileatus*	*Campephilus imperialis*
STATUS	Officially extinct	Not federally endangered	Officially critically endangered
HABITAT	Mature bottomland and swampy forests	Mature bottomland and swampy forests, deciduous and coniferous forests, or wooded suburbs	high altitude pine forests
VOCALIZATIONS	Nasal yank yank similar to a nuthatch or a tin trumpet	The contact call is loud deep kuk kuk. They also use a yucka yucka call similar to a flicker	
SIZE	Larger than pileated. About 19.5 inches long	Crow-sized. About 16.5 inches long	The largest of all woodpeckers
PLUMAGE MARKINGS	A large white patch on rear portion of wings. On each side, a white stripe runs from the cheek down the side of the neck to meet in the middle of the back	The back is almost all black, with white only on the front portion of wing. It is only visible when in flight	Glossy greenish-black, with elongated scarlet crest and white on a portion of the wing
CREST	Male has a red crest with black on the foward-facing part of the crest down to the bill. Female has a black crest	Both male and female have red crest	Male has a red crest, but not the female
BILL	Large ivory bill. But bill color is not a good field mark	Bill gray to black	Yellowish-white

After reading their descriptions, what are the birds pictured in the drawings below?
Are they all different species?



Great job! Next time you are in Louisiana's swamps, be on the look out!

THE PLANTS AND ANIMALS OF LOUISIANA'S PRAIRIE.

Link to our exhibit: "Louisiana's Past: The Louisiana prairie long ago"

GAME 1. DO YOU KNOW WHAT A PRAIRIE IS?

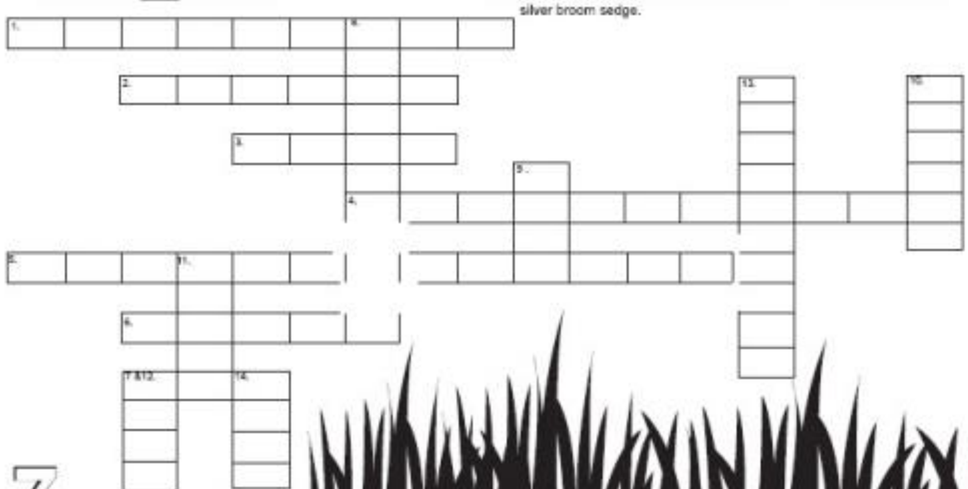
To learn about prairie, fill in the blank in the definition below then use the missing word to fill and complete our crossword puzzle using the questions' numbers as a guide!

ACROSS

1. A prairie is a _______ grassland.
2. It is a plain of grass that gets hot in the _______ and cold in the winter.
3. There are two main kinds of prairies, one is called a tall grass prairie. It is composed of areas with rich _______, moderate precipitation and grasses over 5 feet tall.
4. Most of the interior of North America was a prairie before European settlement radically altered the environment with _______.
5. The other kind of prairie is called a short grass prairie. It receives little _______ and grasses are less than 2 feet tall.
6. These animals can also withstand a great _______ of temperatures, from well below freezing in the winter to sweltering heat in the summer.
7. Animals that live in prairies have adapted to a semi-arid, windy environment with _____ trees or shrubs.

DOWN

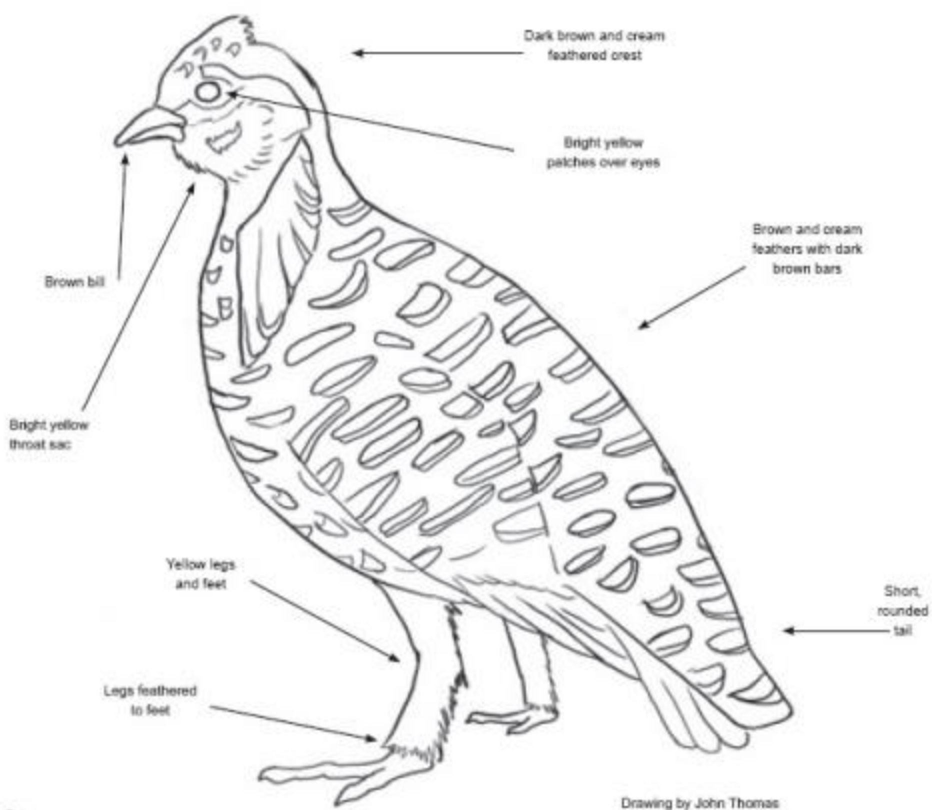
8. Attwater's Prairie Chickens are wild fowl that live in the coastal prairies of North _______. These noisy grouse are strong fliers that are not closely related to chickens.
9. Prairie Chickens have a varied _____. They eat leaves, seeds, rose hips, and insects.
10. Prairie Chickens are in _______ of extinction because of loss of habitat. Much of their prairie habitat has been used for farming.
11. The whooping _______ used to live in Louisiana prairie, but this bird is now extinct.
12. The squirrel tree _____ and green tree _____ also inhabited the prairie.
13. The _______ in the Louisiana prairie was mainly composed of cat tail, marshelder, and carpet grass.
14. In the prairie, you could also find pickerel _____, water primrose and silver broom sedge.



GAME 2. LET'S COLOR THIS PRAIRIE ANIMAL!

Here is one of the animals you could find in the Louisiana prairie long ago. Do you recognize it? Look at the specimen in the museum display to color this interesting animal. If you are at home, use the colors listed on our coloring sheet to help you.

Attwater's Prairie Chicken
(Tympanuchus cupido)



8

APPENDIX E. INTERVIEW SUMMARY

	Tracy	Misty	Sarah	Leslie
Interview Summary	This informal educator discussed the habitat exhibits and animals that are displayed in the science museum. She did not seem to have a clear understanding of the NOS and stated that younger students would need a lot of guidance to understand the science concepts presented in the museum.	Since this informal educator was a retired science teacher, she seemed to be very knowledgeable about what science is, the NOS, and science inquiry. She discussed that their arts and science museum offers a lot of hands on activities that can be carried over into the classroom.	This informal educator was a big advocate of students learning through play and hands on discovery. She did not seem to have a clear understanding of what the NOS was and mentioned that their programming does not include NOS concepts.	This informal educator works with a youth program at the zoo. She explained that the students in her youth program have “education days”, where they sit into a classroom and learn new concepts, but they are mainly learning by volunteering in the zoo and interacting/educating the guests or working behind the scenes in animal housentry.
Q1 Primary Codes (What does science mean to you?)	Being curious, Exploring, Figuring out life	Constantly changing, New ways of thinking	Applying concepts, Understand why something is happening	White lab coats, laboratory, It’s in the everyday, It’s in everything
Q2 Primary Codes (How is science portrayed in your museum/zoo programming?)	Animals, Exhibits	Field trips, Electric circuits, Butterflies, Rotating exhibits, Hands-on activities	STEM or STEAM based projects, Scientific concepts, Careers	School programs, Non formal experiences, Guest engagement
Q3 Primary Codes	It doesn’t	Hands on, Discovery,	We include all sciences	How science works, Explain,

(What aspects of the nature of science- what science is/how it's done- are incorporated into your science programming?)		Challenge, Build, Create		Theory, Hypothesis, Meeting standards, Testing
Q4 Primary Codes (What age group does your program cater most towards?)	All ages, On Special Saturdays 5-12	K-8	Ages 1-8	Youth Program: 12-18, Zoo: Elementary age
Q5 Primary Codes (What is the process that teachers have to go through in order to bring students to your museum/zoo?)	Call, Email, Fill out form	Online lessons (this participate did not really explain a process- she explain how their online lessons can be used in the classroom or teachers can bring students to the museum if the museum is covering a topic that they're teaching)	Teachers submit dates and times	Online, Call
Q6 Primary Codes (Does your science programming offer hands-on	Undergraduate research, Special Saturdays program, Touch	Build, Create	Touch, Play	Volunteer out in the zoo, Educate guests, Work with our animal housentry dept.

experiences for students? If so, please describe.)				
Q7 Primary Codes (What does your science programming offer that can further science inquiry for students?)	Not forced, Inspiration, Meeting scientists, Seeing collections, Driver of curiosity, Ask kids questions	Align program with NGSS, Hands-on, Take activities back to the classroom	Maker's shop, STEAM based, Hands-on, Building, Making, Playing	Access to different opportunities
Q8 Primary Codes (Does your science programming provide activities that connect to the Common Core Standards and/or Next Generation Science Standards for teachers? If so, please provide examples.)	It's outdated so it's not Common Core or the new stuff	NGSS, Bridge Building	We align our activities to the Louisiana state standards	School programs do
Q9 Primary Codes (What do you think makes your science programming stand out from other science programming at other museums/zoos in Louisiana?)	"Cool" factor, Scientists have great stories about expeditions, Collections	Changing, Dynamic, Sophisticated activities, Program for girls in deprived areas	Maker's space, Building, Making, Constructing, Taking things down, Taking things apart, Learning through doing, Kinesthetic learning	Hands-on, Education days, Field trips

Q10 Primary Codes (What science concepts do you hope students learn from attending your museum/zoo?)	Science is done in a lot of different ways	Forensic science, Physical science, Engineering, A lot of different topics	Physical science, Things like gravity, Structural type things, Circuitry	All things are connected
Q11 Primary Codes (How do you think your science program could better students' understanding of science concepts?)	It might be difficult for younger kids	Hands-on, Short presentations	Hands-on, Play, Take apart, Using more of their senses	Active learning
Q12 Primary Codes (How do you think your science program could better students' understanding of the nature of science?)	Meeting the scientists	Having them think like a scientist, We give them challenges, Challenging	We don't have that type of programming	Getting exposure to different people in the field, Project

VITA

Michelle Elizabeth Gomez, a native of Saint Amant, Louisiana, received her bachelor's degree at Louisiana State University in December 2015. She was hired at an elementary school as a special education teacher during her last semester as an undergraduate student; she began to teach following commencement from the university. After teaching for a semester, she decided to continue her education as a graduate student in the College of Human Sciences and Education at Louisiana State University. She plans to graduate with a masters in education in August 2018.