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The Nature of Informal Educators in Science Centers, Science Museums and Zoos: Case Studies of Personnel, Practices, Programs, Outreach and Organization

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The Nature of Informal Educators in Science Centers, Science Museums and Zoos: Case Studies of Personnel, Practices, Programs, Outreach and Organization

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Abstract

Informal Science Centers provide educational experiences for people across the country daily. While the terminology is often similar, there are differences between institutions, often determined by mission, organizational structure, and experience. The purpose of this study was to identify shared experiences and unique characteristics of eight informal science centers around the country. The significance of the study was to add to the understanding of informal science educators' responsibilities, organizational structure, decision making process, and development. Data for the study was collected using qualitative measures through a researcher-created interview, sent to fifteen institutions, after the recommendation from two well-known informal science researchers. Eight organizations agreed to complete the interview process, which was done utilizing a digital platform.

The interviews showed most institutions have similar expectations of their educators and their responsibilities. The data indicated educators have large say in determining programming and outreach direction, often based on interest, resources, and state standards. Additionally, the data showed there were significant differences in how institutions structured their educators organizationally.

The results of this study show the need for informal science centers to continue to evaluate data to determine best practices. Some institutions seemed to have more efficiently and effectively determined best practices. There should be a continued emphasis on evaluations, both programmatically and personally, as several sites did not have a formal evaluative process.

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Dedication

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Chapter I. Introduction

Informal education programs encompass science museums, centers, and zoos where individuals can interact with scientific learning outside of a formal classroom. While museums have been around for centuries (Alexander & Alexander, 2008), the earliest museum models did not provide education. Those first museums held art and philosophical thinking and were open to individuals in the community with wealth (Pittman, 1999). As the age of Enlightenment rushed across the globe, society began to understand museums' importance as places that could be more than collections.

The museum movement in the United States was a bit slower than in Europe. With the opening of the first museum in 1773 in Charleston, South Carolina (Alexander & Alexander, 2008), the spread of museums started, with some of the most well-known museums opening a century later. With the start of the industrial revolution, the government began to educate the public. Museums also began to shift from places that prioritized collection and preservation of antiquities (Nolan, 2011) and began to take a more forward approach to education (Alexander & Alexander, 2008). With the inclusion of education in their accreditation requirements (AAM, 2005), museum education became a formalized institution.

The first museum educators were professional teachers (Roberts, 1997). Over the next century, the education profession became more formalized, with departments added and staffing structure changed. By the early 2000s, museum educators were the focal point of attention within the institution because they had the most interaction with visitors (Tran, 2008).

The purpose of this qualitative study is to identify and intently study eight mid to large-sized informal science institutions that house an educational department within their administrative structure. As shown in the literature review, significant contributions have been offered to museum studies and informal science learning. While there is research about informal science educators, the nature of the job, structural organizations within informal science institutions, and explanation of the roles, responsibilities, and skills educators have been challenging to identify within the present literature.

Statement of Problem

Research shows that understanding science and its impact on life is vastly vital for society's advancement. Miller (2005) found most Americans do not have a robust knowledge of the process and a basic understanding of science. Dean (2005) shared only 20-25% of Americans are “scientifically savvy and alert,” (p.1) and most individuals do not understand primary scientific content or scientific processes. Miller (2005) states that the lack of basic scientific understanding harms the democratic process because people cannot accurately vote on public policies they do not understand. Garlick (2014) discussed the implications of having a non-educated public and explained the public needs to have a basic understanding of science and its processes to make educated and sound decisions regarding policy and hold government officials accountable. In an age of technological thinking, Garlick (2014) believes scientific literacy, a “foundational knowledge and understanding of scientific concepts and processes,” (p.1) and is fundamental in ensuring the public engages in critical thinking (p.1). Durant et Al. (1989) determined the average citizen lags in their understanding of current science. Because of these concerns, experts felt there needed to be a way to communicate science effectively to the nonscientist public. Marincola (2003) believes future policy and funding are dependent on a society actively engaged in educating themselves. Funtowicz and Ravetz (1991) stated the early 1990s brought out the post-normal age of science, which we still are in today, where “facts are uncertain, values in dispute, stakes high and decisions urgent” (p. 138). Scheufele (2015) found that many adults have not learned science in schools and ethics are becoming a driving factor in the decision-making process and high stakes testing and uncertainty within the curriculum. Learning about science in informal sites like museums and science centers can play a vital role in sharing scientific information with an audience that may have not previously interacted personally with that content, particularly in non-school environments.

Museums may be vital in facilitating engagement and encouraging learning and interactions. This may explain why museums in the last century began to shift their focus from just holding and caring for vast collections to those who deliberately interact with the public to support education, engagement, and learning (Friedman, 2010). Museums are positioned to play an essential role in promoting science because of their informal learning environment and resulting opportunities to permit and encourage free-choice learning. The Museum of Science in Boston found that individuals need more than scientific data to have meaningful and lasting discussions. They asked people to make policy decisions and requested they think about three things- scientific evidence, social values, and personal experience. This study showed that providing people with data or information is not enough, but discussions and personal implications play a vital role in engagement and understanding. The former Metropolitan Museum of Art president, Thomas Campbell (2012) , put it best when he said, “nothing replaces the authenticity of the object presented with passionate scholarship. Bringing people face-to-face with our objects is a way of bringing them face-to-face with people across time, across space… (para. 7)”

Purpose of Study

The purpose of this qualitative study was to explore in detail the informal operation and organization of eight institutions known for the quality of their educational practices. This study determined shared characteristics and methods utilized by successful education departments. The research involved educators who work in museums, science centers, and zoos. This study was conducted concerning a phenomenological approach and utilize interviews and survey questions. Phenomenology is a research design that focuses on commonalities found within a specific group's lived experiences to arrive at a shared description of their perspectives (Creswell, 2013).

Conceptual Framework for Study

A phenomenological framework guided this case study. The goal of phenomenological research is to explore and report on a specific group of people's lived experiences to gather and describe their perceived experience with a particular context (Moustakas, 2010). The firsthand experience, shared by participants, yields rich descriptive data which provides the framework for the "lived experience of a particular group of people" (Patton, 2002, p.104). Merriam (2009) believes that connecting the phenomenological approach with the case study method allows the researcher to make meaning and understand the human experience and "the essence and the underlying structure of the phenomenon" (p.23). Merriam (2009) adds, "because case studies are anchored in real-life situations," they create a "rich and holistic account of the phenomenon. The case study offers insights and illuminates meanings that expand its' readers experiences" (p. 51).

Significance of the Study

This study aimed to add to our understanding of the informal educational role and structure of education endeavors of informal science institutions from the perspective of those engaged in such work. Specifically, this study focused on eight institutions identified as places that have useful and current educational programs. While museums and related environments have been the target of many studies, it is challenging to find literature that provides an existing model for strengths and deficits to create a picture of the role they should play in educating society. Informal science institutions played a significant role in the educational process. They host hundreds of thousands of school-aged children each year, along with regular museum visitors. Identifying commonalities shared between successful educational programs would allow me to provide recommendations that could guide future decision-making.

Research Questions

Agee (2009) believes that qualitative research questions "need to articulate what a researcher wants to know about the intentions and perspectives of those involved in social interactions" (p. 432). Moustakas (1994) states that phenomenology as a focus is important because it is designed to study the lived experiences of phenomena from the individuals who live them. The research questions guiding this study are:

Q1: How do informal science educators view their role within the institution's overall environment?

Q2: What were the responsibilities of individuals classified as informal science educators?

Q3: How did informal science institutions determine their educational programming's programmatic and outreach focus?

Q4: How did the targeted informal science institutions report communicating science with the public?

Q5: What did these institutions do to ensure they educate the public?

Brief Overview of Research Methods

To identify an initial pool of subjects, I used a snowball sampling method to determine the initial respondents. John Falk and Lynn Dierking, leaders in museum education, provided the initial recommendations for institutions to participate. Once the case study locations were identified, I interviewed for one to three hours. I also examined information such as museum educators' hierarchical structure within the museum setting and mission and vision statements. Once I was done interviewing all eight informal science institutions, I found commonalities between effective programs.

Assumptions

I have assumed those interviewed for this study were forthcoming in their responses to questions. Additionally, throughout the interviews, the vocabulary was understood in similar fashions by all key stakeholders. Finally, each institution interviewed had a museum education practice currently.

Limitations of the Study

The small sample size placed considerable limitations on the results' generalizability. There were smaller museums with accomplished education departments that are not mentioned because they are not well known. Because museum education is a vast field that plays various roles depending on the institution, this study's findings may not be the same as findings in other institutions. This variety creates a discrepancy between the titles used to describe museum educators. Another limitation was the lack of industry-wide training for educators. While the need for effective science communication is vital, two studies found that scientists with technical information have received little to no training in how to communicate effectively, and public members who advocate for science often have communication skills but little to no training in the field of science (Dunwoody et al., 2009; Neeley et al., 2015). This research was conducted with several limitations. A considerable limitation was that as one researcher, I only conducted this research. The sample size was determined using snowball sampling, but I only received two independent parties' suggestions. There could be informal science institutions utilizing various best practices that I was unable to interview. There were several institutions I reached out to via email that did not respond. Additionally, this dissertation only includes one educator or supervisor's opinions from each institution. There may be others employed that have varying opinions.

COVID-19 was another limitation of my study. When this research was proposed, I planned to travel to several places and conduct interviews and engage in observations. When COVID-19 shut down travel and institutions, I had to pivot to virtual interviews and no observations. During the talks, many people provided two different answers: pre-COVID-19 practices, and their current practices. I worked closely with the Director of Evaluation at the Perot Museum, but COVID-19 impacted her employment status, and I lost touch with her.

Delimitations

When selecting the sample group for this study, I used recommendations to identify the additional case studies. Through this process, I could not interview every individual who considers their work to be that of a museum educator. Additionally, the observations I made of their work were over a limited scope of time, so I did not observe every aspect of their work. The interview protocol needed to be conclusive and extensive to identify the various factors of the education program at each institution.

Chapter II. Literature Review

Science museums, centers, and zoos are essential to informal learning because of their flexible environments. Mooney and Kirshenbaum (2009) found less than one fifth of American's can list a scientist or name a scientific institution. They also discovered that for every five hours of cable news, one minute is dedicated to something of scientific nature. These troubling statistics highlight the importance of creating opportunities for people to interact with science in a non-threatening environment. These informal institutions afford people chances to learn about a variety of topics. The addition of museum educators extends the institution's ability to provide opportunities for visitors to learn and create new meaning.

This literature review provides the context for this study by reviewing research and writing done on the topic of education within informal science environments. The first section of the review examines informal science learning, free-choice learning, and scientific literacy. The second section provides an overview of the history of museums, science museums, science centers, and zoos. In the third section, I review the history and nature of museum educators and take a closer look at science instruction within museum environments.

Advantages and disadvantages to science learning are covered in the fourth section. In the final section, I discuss the educational structure within informal science environments. The terminology used for the educators within informal environments varies between institutions, so this section examined a variety of terms.

Informal Science Learning

Informal science learning is defined by the National Science Teachers Association as time spent learning science in informal environments, or outside the formal classroom settings (NSTA, 2012), essentially knowledge acquired outside of formal schooling. Bevin et al. (2010)

found that learning science in informal environments is important because there is evidence to show that these experiences can enrich in-school science learning. For the purpose of this study, informal science learning referred to any learning that happens outside of a formal classroom. The National Research Council (NRC) report *Learning Science in Informal Environments: People, Places, and Pursuits* (2010) divided informal science learning into three categories:

> Everyday Informal Environments which include different media, conversations, pursuing one's hobbies, Designed Environments- zoos, museums, science centers, libraries, environmental centers, aquariums, and planetariums and Programs, which include different science clubs, after school activities. (p.47)

This report also detailed the elements of an informal learning environment and stated

> These characteristics include engaging participants in multiple ways (physically, emotionally, and cognitively), encouraging participants to have direct or media-facilitated interactions with phenomena from the natural world (and from the designed physical world) in ways that are largely determined by the learner, providing multifaceted and dynamic portrayals of science, building on the learner's prior knowledge and interest, and allowing participants considerable choice and control over whether and how they engage and learn. (p.4)

Falk (2002) reported that "research suggests that nearly half of the public's understanding of science derives from [the informal and free-choice learning] sector, which supports the on-going and continuous learning of all citizens" (p. 63). The NRC (2010) report found that informal learning has an advantage when taking place in science museums because they are open to a wide range of populations with varying levels of interest and knowledge.

Learning that takes place in informal science centers is vastly different than learning that takes place in formal classrooms (Cook, Reynolds & Speight, 2010). Museum learning often is self-directed, guided by internal motivation, and often unpredictable (Hooper-Greenhill, 1994). Falk and Dierking (2006) found that museum learning happens in short bursts of time and is driven by the individual's own curiosity. Taylor & Neill (2008) defined non-formal education as "participatory, flexible, less standardized, and more responsive" (p. 24). Grenier (2010) said individuals need the power to decide their own learning objects, and museum staff should work to create a space that allows for them.

Free Choice Learning. The term free-choice learning was created by Falk in 2001 and is used to describe learning available outside of a formal classroom environment in which individuals have control and choice in what they are learning. In 2010, Falk and Dierking found that adults spend 95%+ of their time learning, while either at work or while pursuing hobbies. Even children spend only 20% of their time in schools, so free-choice learning is instrumental in educating children (Falk, 2019). Falk also found that most people engage in free-choice learning to better satisfy their own personal sense of identity, to find value in the world around them, and fulfill their own educational and personal needs (2004).

While non-formal and formal learning has different facets, there are some commonalities that occur at the same time (Malcolm. Hodkinson & Colley, 2003). Taylor (2006) found there can be a large amount of formal learning that occurs in informal environments ~~(2006)~~. Falk (2005) found that people participate in free-choice learning for a variety of reasons, but only rarely to become an expert. He also suggests most individuals participate in free-choice learning to "satisfy a personal sense of identity, to create a sense of value within the world and to fulfill personal intellectual and emotional needs" (p. 268).

Scientific Literacy

Scientific literacy plays a key role in science communication because effective science communication can lead to understanding. Jon D. Miller (2007), one of the major researchers working on public perception of science states, "we should take no pride in a finding that 70 percent of Americans cannot read and understand the science section of the New York times" (p.2,) Henriksen and Froyland (2000) believe there are four main arguments for science literacy:

practical, democratic (civic), cultural, and economic (professional). Experts like Miller believe scientific literacy is important because it is a civic responsibility of the government and schools to craft a scientifically literate society to ensure they can be educated on policy issues as adults (Miller, 2010). Coffee (2007) believes society has a cultural responsibility to be scientifically literate as it is part of the American heritage. Individuals with STEM-related skills also have a better opportunity to hold a job with competitive pay (National Science Board, 2012). Whether the concern regarding science literacy is tied to a moral or economic issue, it only has grown to support the worry that the United States is not proficient in even the most basic sciences (Miller, 2010). Experts define science literacy as the ability for an individual to understand scientific concepts, analyze science viewed through various media, and tie old knowledge to a new understanding, especially outside of the school setting (Snow & Dibner, 2016).

Scientific Literacy plays a significant role in understanding science and being able to apply that understanding to everyday life. Hacking, Goodrum, and Rennie (2001) state

> Scientific literacy is a high priority for all citizens, helping them to be interested in and understand the world around them, to engage in the discourses of and about science, to be skeptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being. (p. 6)

Researchers have found that museum experiences can directly impact scientific literacy (Kimche, 1978; Koran & Baker, 1978; Tressel, 1980; Falk, 1982). While scientific literacy plays a vital role within the context of science communication, it only has a limited role in forming perceptions and decisions (Nisbet and Scheufele, 2009).

Bonnie Kalberer (1994), director of the National Institute of Health Office of Science Education, said, “every day, people have to deal more and more with scientific, technical, and mathematical issues. And, if they’re not prepared for that, one could say your whole democratic system is in jeopardy." (p. 3) Mooney & Kirshenbaum (2009) researched for their book *Unscientific America* and found

> Just 18 percent of Americans know a scientist personally, according to survey data, and even fewer can name the government's top science agencies . . . When polled in late 2007 and asked to name scientific role models, 44 percent of people [could not] . . .produce specific names, the top selections were either not scientists, or not alive: Bill Gates, Al Gore, Albert Einstein (p.4)

These findings show the importance of educating the public on who scientists are and the work they are currently completing. As shown above, society needs to be actively engaged in science and policy making because it impacts their lives.

Museums: A Brief Introduction

The term museum dated 367 BCE and came from the Greek word *mouseion,* a place of contemplation or shrine for the Muses, the patron divinities of the arts in Greek mythology (Alexander & Alexander, 2008). Many great empires, including China, Greece, and Rome, used this early museum model, held items that represented their culture and conquests. Museums have long been environments for both teaching and learning. The Romans used the same term to describe a place used to hold a philosophical discussion. The Alexandria (Eqypt) Museum was one of the first such institutions on record and housed both art and was used as a philosophical academy or early think tank (Pittman, 1999). Hundreds of years later, the number of private museums increased and became more available to the public because of Western Europe's impact on the arts (Alexander & Alexander, 2008). The early museums were often places that displayed the country's wealth, highlighting cultural treasures and items of great economic value. Such museums often had limited access for society, only allowing the wealthy and educated access. The importance of collecting and preserving antiquities slowly began to spread through Europe during the late 18th century as society began to understand the importance of maintaining historical items of significance (Impey & McGregor, 1985). Due to the Enlightenment era, museum creation increased in the 18^{th} and 19^{th} centuries (Alexander & Alexander, 2008).

In the United States, the museum movement slowly increased in the 18^{th} century (Alexander & Alexander, 2008). The Charleston Museum in South Carolina was the first museum on record in the United States and was opened in 1773. Some of the most well-known museums, including the American Museum of Natural History in Washington D.C and the Metropolitan Museum of Art in New York City, were established a century later. A British man, on a trip through the United States, reflected:

> In America, Museums are almost always the property of some private individual, who gets together a mass of everything that is likely to be thought curious – good, bad and indifferent – the worthless generally prevailing over the valuable. The collections are then huddled together, without order or arrangement; wretched daubs of painting, miserable waxwork figures, and the most trifling and frivolous things are added and there is generally a noisy band of musicians, and a juggler, belonging to the establishment, to attract visitors. Mere amusement, and that of the lightest and most uninstructive [sic] kind, is the only object sought in visiting them. (Roberts, 1997, p. 25)

At the beginning of the industrial revolution, as individuals moved in mass towards urban centers, the local government took a more considerable responsibility to educate the public. This movement changed the role museums played, as they were viewed as places that could educate society. Museums took a more forward approach to education at the start of the 1900s because individuals felt museums represented a critical aspect of a democratic society (Alexander & Alexander, 2008). Weil (1997) believed "the museum was established to raise the level of public understanding…to elevate the spirit of its visitors" (p. 257). Throughout the 1960s and 1970s, conversations about equity and access began to shape the views on what was important and the driving force behind creating new museums (Weil, 2002).

In 1952, a meeting held by the United Nations Educational Scientific and Cultural Organizations had conversations about museums' role in society. This was the first recorded time a discussion was held about museums' use as educational institutions on an international scale (Singh, 2004). Up until this point, museums may have reiterated the importance of education as a part of their core values but had failed to provide resources for it (Carlson, 2004). As the museum field continued to see the importance of formalizing education and its role within the museum environment, the American Association of Museums established a committee in 1973 to suggest topics colleges and universities might provide based on museum education (Glaser, 1990). The formalization of education as a cornerstone in museum offerings' architecture had begun. In the 1990s, AAM listed museum education as an accreditation requirement (AAM, 2005). Large numbers of museums placed a large emphasis on education (O'Neill, 2008), and some even had entire spaces reworked to better support the increased attention to education (Czajkowki & Hill, 2008). Talboys (2011) found that with the increased focus on education, hiring and employment practices began to change. By 1998, over 70% of the 10,000 museums surveyed reported employing at least one full-time educator on their staff (Institute of Museum and Library Services, 1998).

Throughout the last half of the twentieth century, from the 1950s to 1988, museums increased in number by 75% (American Association of Museums, 1994). Visitation rose steadily in the United States, from 350 million annual visitors in 1970 to 850 million annual visitors in 2010 (American Association of Museums, 2011). Alexander and Alexander believe this increase in visitor ship, especially school-aged children (over 90 million in 2010), directly results from museums' role as educational facilities (Alexander & Alexander, 2008).

In the 20th century, two organizations formed to create museum etiquette and standards: the International Council of Museums (ICOM) and American Association of Museums (AAM). In 1962, AAM created a formal definition for the term museum:

> An organized and permanent nonprofit institution, essentially educational or aesthetic in purpose, with professional staff that owns or uses tangible objects, cares for them and exhibits them to the public on some regular schedule. Museums are incredibly diverse and range from arboretums and art centers to youth museums and zoos (p.3)

A more modern definition of the term museum, from the International Council on Museums, is

> A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates , and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study, and enjoyment (para 3).

This organization recently proposed to update the modern definition of museums to:

> Museums are democratizing, inclusive and polyphonic spaces for critical dialogue about the pasts and the future. Acknowledging and addressing the conflicts and challenges of the present, they hold artefacts and specimens in trust for society, safeguard diverse memories for future generations and guarantee equal rights and equal access to heritage for all people. Museums are not for profit. They are participatory and transparent, and work in active partnership with and for diverse communities to collect, preserve, research, interpret, exhibit, and enhance understandings of the world, aiming to contribute to human dignity and social justice, global equality, and planetary wellbeing. (ICOM, 2019, pp.3-4).

Therefore, we may define museums as non-profit institutions, inclusive and open to the public, which acquires, conserves, researches, communicates. and exhibits the tangible and intangible heritage of humanity and its environment for purposes of education, study, and enjoyment while safeguarding memories for future generations and providing equal rights and access to all. Many researchers believe that museums' innate nature encourages and nurtures learning (Falk & Dierking, 1992, 2000; Falk, Koran, & Dierking, 1986; Oppenheimer, 1975). Tishman (2005) believes museums embody learning because they are places that value things worth learning. Over the last decade, museums have begun to focus their missions to make learning a more prominent part of their mission. Tishman states that museums are effective communicators because they utilize active learning and personal agency. In active learning, individuals act on the information provided to them and use it to draw new conclusions. The personal agency brings into effect the decision-making abilities one has when in a museum.

People get to utilize free choice when deciding what exhibits they should interact with—combining these two things set museum environments up to be effective communicators of science. Even though museums have been considered important institutions of education, the thought they could promote inquiry-based learning is a newer one (Henriksen & Froyland, 2000; Ucko, 1985). The Exploratorium, in San Francisco, was one of the first informal science learning environments to offer this idea of interactivity and engagement. Founded in 1969 by Frank Oppenheimer, the Exploratorium has been instrumental in driving the connection between formal and informal science learning.

> The old model of the science museum, [where] visitors looked at displays of artifacts. And instruments and read the signs to decipher what was in the glass cases. But at the Exploratorium and other new museums, exhibits were taken out from behind the glass and set up so that visitors could interact and play with them" (Klages, Librero, & Bell, 1995, p. 4).

Museum Leadership Structure. As museum numbers grew, many experts questioned whether working in a museum equated to a profession (Alexander & Alexander, 2008). The AAM began publishing two periodicals designed to inform practice and guide development. They also determined a formalized accreditation process was needed and in 1970 adopted the approach used to this day. Creating an accreditation process was a vital step in developing standard operating procedures and felt it would provide credibility for the museum world (Alexander & Alexander, 2008). The accreditation process held museums accountable to their mission and vision and helped advance the museum's ethical and professional practices.

Over the last century, there have been many changes in museum staff's organizational structure (Lord & Lord, 2009). While most museums started structured around their collections department and lead curators, the shift from collections to outreach saw a change in staffing practices. Currently, most museums are organized by their three main functions: administration, assets, and activities (Lord & Lord, 2009).

At the top of the administrative structure is a museum director. Some institutions refer to this role as a CEO. This individual is responsible for overseeing all museum elements. Alexander & Alexander (2008) found the director role was vital due to the increased management responsibilities required to run a thriving institution. These individuals must be flexible and adapt to change swiftly (Suchy, 2000) and supervise individuals with a wide range of skills (Boylan, 2011).

Science Museums: An Introduction

As museum numbers and attendees increase, museums switch their focus from traditional research and collections to public learning institutions. Hein (1998) stated that "the public museum as we know it- displaying objects for the edification and entertainment of the public- is a product of the 18th century" (p.3). Museums began to shift their function from places of collection and preservation to those of research and education (Nolan, 2011). Heir (1998) found that as the government took increased responsibility for providing public services, such as education, museums' view switched to a venue that could educate the masses. Bell et al. (2009) argued that "museums are rich with real-world phenomena, these are places where people can pursue and develop science interests, engage in science inquiry, and reflect on their experiences through sense-making conversations." (p.2)

Friedman (2010) believes the most noticeable shift from science museums as collections-based to science museums as places of education happened with *Palais de la Decouverte* (Palace of Discovery) in Paris in 1937. This was the first science museum that deliberately did not include collections or research in their building, as their focus was public education. Jean Perrin accomplished this goal by allowing visitors to see active science by opening laboratories to the public. This method was so successful that they could turn a temporary exhibit into a permanent museum. In Philadelphia, the Franklin Institute was one of the first museums in the United States to present visitors with a hands-on science approach. Hands-on learning is an active type of education that involves the use of tactical experiences to gather information (Korwin & Jones, 1990). According to Meinhard (1992), hands-on learning means “students have objects (both living and inanimate) directly available for investigation” (p.2). When opened in 1934, it had the nickname “Wonderland of Science” (Mission and History, 2020, para 4). The museum offered classes on mechanics and engineering and promoted science discovery and innovation. This model for hands-on, experiential learning is still widely used to this day.

Farmelo (2004) studied several museums that began displaying current science within their collections. The Welcome Win at London’s Science Museum, Current Science & Technology Center at the Boston Museum of Science, and *La Cite Des Sciences et De L’industrie* (The City of Science and Industry) `in Paris are just a few of the museums working on merging historical information current trends within the same building (Farmelo, 2004). The American Alliance of Museum's annual report shared several key facts in support of the museum's impact: they provided $704 billion annual industry, spend more than $2 billion a year on education activities (AAM, 2013), sustain more than 400,000 jobs (AAM, 2013), host over 850 million visits each year to American Museums (AAM, 2013) and are the ranked the most trustworthy source of information in America including over the local paper, college professors, and the government.

Science Centers: An Introduction

The Association of Science-Technology Centers (ASTC) believes one distinction between science museums and science centers is that individuals can determine the pathway they follow when interacting with the experience and are provided minimal curriculum. These centers focus primarily on outreach and education and don’t have collections within their building. Science centers provide people with firsthand experience as they interact with science in a hands-on approach and allow visitors to drive their curiosity. They also state, “science centers and museums are uniquely positioned to raise awareness, understanding, and interest levels in science and the other STEM disciplines” (Association of Science-Technology Centers, 2013, p. 7). Paulette McManus (1992), a museum researcher, found a noticeable shift in the last generation regarding museums in which museums became more concerned about representing ideas and less concerned about representing objects. As a part of this shift, she found two different categories within museum science communication: thematic exhibitions and science centers. Danilov (1982) has engaged in significant research on the creation and proliferation of science museums and found their technical museums' roots. In the 1960s, with the creation of institutions such as the Exploratorium, science center's became standalone institutions. Thomas (1994) researched visitor numbers and found an estimated 714 visitors per square meter in Launch Pad (a set of interactive exhibits) compared to 44 visitors per square meter to the rest of the science museum in a day. These statistics supported Danilov’s prediction that “science and technology centers played a more vital role in informal education throughout the world” (Danilov, 1982, p. 49). That same year, Stevenson (1994) researched attention spans in museums vs. Centers and found that visitors showed little to no concentration lag after 60 minutes in a science center.

In contrast, in science museums, fatigue tended to set in around 30 minutes. These landmark studies were critical in solidifying the importance of science centers in the informal learning world. As learning and learning styles continue to change, science center's play a vital role in engaging learners in hands-on activities, promoting the goal of making science accessible to all.

Zoos. The educational focus differs slightly from other informal science learning locations. One focus zoos highlight is conservation. Mission and vision statements align with the institution's work and the conservation standards set out by the American Zoo Association, or AZA. Martin (2001) found these goals are accomplished by providing signage with adequate descriptions, offering educational programs, and ensuring sufficient staff interactions, both educators and other support staff, with visitors. Information supplied to visitors should follow a central mission or theme to ensure understanding (Bronchu & Merriman, 2002). Zoos, historically, were places of entertainment, but overtime, they have become increasingly more educational (Falk, 2006).

While zoos have worked to provide educational experiences, research shows most people visit zoos to relax, spend time with friends and families, and viewed the experiment as more recreational than academic (Falk et al., 2007; Ryan & Saward, 2004). Even though visitors may participate in educational experiences while on-site, many self-report that was not their primary reason for visiting (Morgan & Hodgkinson, 1999). Wagoner and Jensen (2010) suggest that zoo learning must interact with former understandings to develop new ideas.

This creates a unique challenge for educators who balance entertainment and education. Many zoos will state visitors' education is one of the most important goals (Fernandez et al., 2009; BIAZA, 2018), but it is not a clearly understood zoo factor (Fernandez et al., 2009). Jensen (2014) feels there is not enough research on zoos and their impact on education, especially because they are increasingly under pressure to justify keeping animals in captivity. Esson (2009) stated that

> Zoos are between a rock and a hard place when it comes to substantiating claims to be education providers,' as thus far, the literature on zoological education does not confirm

> the ambitious mission statements of zoos as education providers, particular with regard to the conservation of biodiversity; perhaps even used this educational function as part justification for their existence. Because of this, the burden of evidencing educational impact falls squarely on the shoulders of zoos. (p.1)

This unique tension between education and entertainment added to increased public pressure for justification of previous practices makes zoo education more critical now than ever.

Museum Educators: History and Nature

There is not much research or publications on museum education or museum educators' history. According to the American Association of Museums (2005), museum educators help museums fulfill their educational mission through outreach, engagement, and curriculum implementation. Educators recognize that many factors affect the personal, voluntary learning that occurs in museums and seeks to promote the process of individual and group discovery and to document its effect. On museum teams, museum educators advocate for visitors and provide meaningful and lasting learning experiences for a diverse public.

> At their start, museum educators began to arrive at the same time as education began to take a progressive approach in America. ―More than anyone else, educational reformer and philosopher John Dewey helped to make education central to the museum's mission and greatly influenced the children's museum movement. Dubbing desks, blackboards, and textbooks as ―dull drudgery, he called on teachers to look beyond the schoolyard to create real-life experiences for students who could ―learn by doing. (Schwartzer, 2006, p. 9).

John Cotton Dana, the Newark Museum founder, felt museums were successful if they housed objects that were useful for schoolwork. Peniston (1999) was unambiguous in his opinion that museums were not schools:

> A museum is not a school; it cannot afford to become a school, and by its own unaided powers it can do little educational work of the formal kind. Fortunately, it has close at hand a multitude of educational institutions: 19 schools – public, private, and parochial; universities, technical institutes; professional and business colleges. Cooperation of museums with them has been tried in many places to a moderate extent, notably in Newark, and always with fair success. The museum as an aid to teaching institutions of every kind seems to be in its proper position‖ (p. 198).

As museums continued to grow during that time, literature referring to educators is sparse. As we entered the 20th century, educators became more commonplace in the literature. Roberts (1997) stated the first museum educators were hired before World War 1.

> Many of these early instructors were schoolteachers – a fact that would later hinder museum educators bent on differentiating themselves from the more formal education field. Nevertheless, they established educator' first professional niche in the institution, which soon led to the formation of autonomous education departments (Roberts, 1997, p. 33).

After the Second World War, the term museum educator became even more well known. Articles began to be written, and their jobs began to be shared. Grace Fisher Ramsey, a museum researcher during the 1920s and 1930s, began to research education within museums. She felt museum educators had secured their space as a vital part of the staffing structure, but "if they were to continue to advance, the next stage of development required that they address their training and promotion within the institution" (Ramsey, 1938, p. 43).

During the Great Depression, philanthropic giving drastically decreased, and nonprofits could no longer solely rely on wealthy individuals to bankroll their facilities. Museums found themselves in a challenging position. While the Works Progress Administration funded various educational offerings, including libraries, they did not fund museums because they felt they were seen as private institutions that did notemploy many people (Cremin, 1988) As the Cold War edged closer, museums again found an opportunity to place themselves in a position of importance. The federal government's creation of the National Endowment for the Arts and the National Endowment for the Humanities was created during the 1960s, which opened the option to fund museums (Robbins, 1969). The emphasis was shifted to diversifying museum staff, bringing museum educators to the front through increased funding. Falk and Dierking (1984) asked museums to focus their research agendas on "learning as it differentiated itself from school learning" (p.12). They also asked educators to shift from gathering quantifiable evidence and focus more clearly on qualitative evidence. With the authorship of *Museums for a New Century* (1984) came sixteen recommendations for the next generations of American Museums, with one-third of them tying to education:

> Recommendation 5: Education is a primary purpose of American museums. To ensure that the educational function is integrated into all museum activities, museums need to look carefully at their internal operational structures. Recommendation 6: We urge a high priority for research into the ways people learn in museums. Recommendation 7: AAM and other professional education and museum organizations [should] begin an effective dialogue about the mutually enriching relationship museums and schools should have. Recommendation 8: We urge that museums continue to build on their success as centers of learning .and pay new attention to their programs for adults. Recommendation 10: Museum work merits professional compensation. We urge that each museum develop responsible compensation policies and practices that bring its salaries and benefits into line with professional work for which similar education and experience are required. Recommendation 11: We strongly believe the museum community must address the underrepresentation of minorities in the museum workforce generally and the underrepresentation of women in higher management levels. (American Association of Museums, 1984, pp. 31-35).

Finally, with the beginning of the 21st century, museum educators became a commonplace title. Research and recommendations came from several organizations on museums' educational role in society. With the release of *Excellence and Equity: Education and the Public Dimension of Museums* (American Association of Museums, 1992), it was recommended that the primary focus of museums shift from just gathering and preserving collections and begin to accept education as the heartbeat of the institution. Continuing into the 2000s was the momentum of education departments playing a vital role in the museum's administrational structure.

Tran (2008) found museum educators to be the focal point of attention because they interact with museum researchers and museum visitors. Museum educators are often the individuals who encourage internal and external collaboration (Henry, 2006). Even though a museum educator's work is vital, there is not much research on their work's overall impact (Tran, 2007; Phipps, 2010). The museum educator's actual work is often determined by the museum they serve, guided by their mission and goals. (Ljung, 2009; Tran, 2008b). Cunningham (2004) shared museum educators engage with visitors in several ways

> including structured interactions, such as museum tours, stage shows, or classroom programs, in which the length of interaction and the relationship between visitors and staff are largely predetermined, and unstructured interactions, such as unscripted conversations between staff and visitors at activity tables or exhibits (p.5)

One interesting trend noticed throughout the literature was the perceived disconnect between knowledge and application. Schouten (1987) found that while museum educators often have in-depth knowledge about a topic, they do not have training on learning strategies, leaving them unprepared to train docents (Wolens, Spires, and Silverman, 1986).

Science Instruction in Museum Environments

Over 2,500 years ago, early collections were created to display their local society's wealth and were often very limiting to the individuals they allowed into the institution. Both the International Council of Museums (ICOM) in 1986 and the American Association of Museums (AAM) in 1993 were formed to create a set of museum standards and give directions towards the growing museums for the future.

As the industrial revolution encouraged massive numbers of people moving to larger cities, governments began to feel an increased responsibility in educating their citizens. The museum environment began to be considered a place that could educate people (Heir, 1998). In the early 1900s, museums, which would now be called science centers, began to open that had no collections or research in their building (Friedman, 2010). Visitors could participate in an experiment related to something found in the institute or learn about scientific concepts found in the natural world. Other museums, including the London Science Museum and the Boston Museum of Science, worked to balance exhibits and education by ensuring a focus was placed on both (Farmelo, 2004). Nearing the turn of the 20th century, Falk and Dierking (1992) discovered that some museums emphasized education over the exhibition. Today, museums around the world exhibit artifacts and provide interactive experiences with a variety of scientific topics. This noticeable shift from institutions that displayed objects to institutions that educated its visitors was a prominent example of museum culture change. It ushered in museums' modern-day structural organization, including the inclusion of educators. On museum teams, museum educators serve as audience advocates and provide meaningful and lasting learning experiences for a diverse public.

Advantages of Education in Museum Settings

Museums play a unique role in their visitors' education because they offer learning opportunities not found in other places. This section highlights several advantages to informal science education, including access to resources and ease of access. Visitors choose which exhibits they interact with and can guide their progress. Some informal science experiences allow individuals to drive their learning, and other institutions assist in tours, guided adventures, and programs. Museum educators are an essential component in the outreach afforded through these institutions as they allow visitors to ask questions and engage in new conversations. Accessibility to well-designed, visitor-tested programs, the museum's objects, and the natural connection between science and scientists create unique opportunities for the museum educational environment.

One advantage of museum education is the accessibility to programmatic offerings once you are in the institution. Bowers (2012) found that around 80% of museums provide educational programming, and museums spend more than $2 billion a year on educational activities and outreach. The museums that do not offer formal educational programming were often small museums with space or collections limitations. These statistics show evidential proof that museums are working to provide education to the visitors that enter. These informal science environments have different facilities and abilities than a traditional classroom; children will most likely interact with science differently when in a museum. Lawrence and Tinkler (2015) concluded with research in cooperation with the National History Museum in London that many science museums no longer portrayed a fixed image of science. A large push to engage visitors with current activities may feel ill-equipped to teach children about science and set up to be successful because most museum exhibits provide the supplies and knowledge necessary to understand a concept.

Successful museum educators can also use the museum environment as the backdrop for their work. Instant access to displays, models, and artifacts affords communicators the ability to engage with science differently. Lebuffe (1994) found that children learn better when they can find answers for themselves rather than read the book's answer. Educators are in a unique position because they can interact with the public and direct them to other places in the museum that may interest them. Technology also extends educators' reach, as I have observed online teaching with various platforms.

Another advantage to science education programs in museums is the natural connection between the scientist and the science exhibits on display. After interacting with every significant science museum website, it was interesting to note that some museums employ scientists on their staff. When researching further, these museums appeared to be those institutions that placed research as an essential component of their mission. These individuals actively work to facilitate research, outreach, and innovation. The easy access between the scientist and the public is formed through a science communicator's bridge. Communicators can interact with scientists within their institution, learning about what they are doing and researching. This automatic exchange of information ties people to the research conducted at a specific institution. Visitors may be more willing to bring friends back to show them what they learned or saw. Scientists often don't have the skills to engage with the public effectively, but utilizing an intermediary, such as a science communicator, provides someone in the middle who can understandably explain information.

Challenges to Education in Museum Environments

While most museums are an excellent environment to support informal science learning, they face several unique challenges when providing educational opportunities. As we will see in this section, the lack of educator preparation, both classroom and museum, barriers to access, the rise in social media, and evaluation access are a few challenges museums face in the education domain.

There are several disadvantages to science communication and learning in museum environments. One burden of learning in the museum environment tied directly to classroom students is the perceived lack of preparation on the educator's part. Tal el. Al. (2005) found most teachers interviewed visiting a museum did not know why they came to the museum and had not planned any follow-up educational activities. This same study found that most teachers did notview a visit to the museum as an educational activity but rather a fun experience. Tal et al. (2005) surmised that most teachers don't spend much time planning a field trip or creating follow-up experiences. These disconnects between the museum environment and the classroom could cause misconceptions to form and deliver.

Another disadvantage of learning in the museum environment relates to barriers. In a North American study of museum visitors with Latin-American backgrounds, individuals reported feeling unwelcome, the price was too high, the language was too complicated, and the activities provided were unimportant (Rahm, 2010). Another study found that most museum visitors come from an affluent and ethnically dominant background (Bell, Lewenstein, Shouse, & Feder, 2009). Other research shows that those who visit one informal science environment (science museum or science center) are more likely to see another similar environment (Falk et al., 2012). These barriers represent unique challenges to educators as they are not only working to engage visitors who come regularly, but they are also working to identify and address an entirely different population of people with whom the educator may not be as familiar. Another barrier to access may be applying what the educator knows. One exciting trend noticed throughout the literature was the perceived disconnect between knowledge and application. Schouten (1987) found that while museum educators often have in-depth knowledge about a topic, they do not have training on learning strategies, leaving them unprepared to train docents.

Finally, Brown and Ratzkin (2011) found that museum visitors have come to expect flashy exhibits and participatory offerings with the rise of social media. This expectation can be challenging for educational departments to tackle, as they are working to grab and maintain attention rapidly. For science communicators, the added pressure of competing with a world of technology and rapid information is a continual problem. Communicators don't have to be sought out as the only person with vital information because society can find the information online. These people must create innovative and engaging experiences that instantly grab and hold their audience's attention. Social media also creates a unique challenge because not all information shared is factual. While this could be a risk faced by anyone, the oversharing of factually incorrect videos is something I have witnessed on various social media platforms.

The Educational Structure in Science Museums

As museums shifted from a collections-focus to one that included education, staffing structure changed to reflect the new focus (Lord & Lord, 2009). The independence that museums have taken when organizing educators, programs, and communications staff plays a large role in the mission and vision of the institution and the goals of their outreach. In today's world, most museums are organized by three distinct areas: administration, assets, and activities (Lord & Lord, 2009). There are various terms that many educators are called, including docents, educators, guides, and communicators. While these roles are typically housed within the same department within an institution, they serve different purposes. This section will provide definitions for the variety of jobs found within education departments at museums using the American Alliance of Museums directory of partner museums.

The Role of Docents in Museum Education.

Burcaw (1997) defined docents as trained volunteer educators and guides. A 2002 study conducted by Sachatello-Sawyer et al. found nearly 88% of all museums offer some guided tours and are the most widely provided educator service in modern museums. Docents can also be referred to by teachers, interpreters, gallery educators, or tour guides. Kidd and Kidd (1997) found that docents often work in museums where they have some interest such as science or art. These individuals often spend time in the museum educating visitors because they are interested in the field and want to share their knowledge with others (Jones, 2012). Many docents are retired and use this role to continue learning and giving back (Abu-Shumays & Leinhardt, 2002). Most docents are in collections-based organizations, including museums, zoos, aquariums, and nature centers (Allen & Crowley, 2013). Docent training looks different, often dependent on their role within their organization. For many institutions, docent training consists of lectures from others within the museum, readings, and other experienced docents' observations (Grenier & Sheckley, 2008). According to Grenier (2005), "without training reflective of engaging programs that encourage questioning, interaction and experimentation, docents will likely continue to lead tours in a manner that mirrors their prior learning experiences in schools and docent training" (pg. 6).

For many visitors, docents are the only individuals associated with the education department with which they will interact. This finding is primarily factual for school visits and field trips (Cox-Petersen et al., 2003). While museums and other informal learning environments provide an opportunity for students to interact with learning in a new way, many field trips model the formal learning environment found in a classroom (DeWitt & Storksdieck, 2008). Bevan & Xanthoudaki (2008) believe this traditional experience is provided because museum educators often apply the pedagogical strategies and skills they experience when they share their own experiences, which can create bias or misconceptions. If a docent does not understand something, they may be more likely to pass that misconception on to the visitor. This formalization of informal learning environments can be unfortunate because students miss the opportunity to interact with learning in a new way. When the structure of museum experience is structured as a formal classroom experience, students cannot explore in a new way. Field trips should allow students to interact with information differently while connecting further information to former understandings. Tran (2006) conducted in-depth research on docents teaching styles and goals and found that docents expect students to utilize prior knowledge and make connections to real-world learnings to have a positive experience. Through observation and interviews, Tran found that educators have a minimal skill set to utilize strategies, and because of this lag, students leave not engaged and dis-interested.

Museum Educators: A Brief Description

The role of those engaged in education in museums has changed over time. Due to education was previously a secondary job at museums and often funded by outside sources, educators were not an essential function of the central structure (Talboys, 2011). The educator's role may change over time and often be based on the individual's skills and personality (Henry, 2006). Some experts argue that museum educators should continue to take a more central leadership role due to the increased emphasis on education (Czajkowski & Hill, 2008).

These individuals are paid staff members who work in museums and are responsible for carrying out any educational focuses and goals the museum has (Tran, 2008). Educators also create, develop, and begin educational programs for schools and the public alike. Museum educators who were only responsible for education within the museum started to appear at the start of the twentieth century (Hein, 2006). These individuals were often schoolteachers who were assigned to a local museum rather than working at a school. At the start of the 1960s, museum education became a distinct field, no longer just pulling teachers from local schools but professionalizing from within (Boylan, 1987).

According to Hein (2006), educators are the individuals within the museum who bridge the collection, culture, and knowledge found within the institution making these elements accessible to the visiting public. Tran (2007) found that despite the importance of the work, research on educators and their impact within the museum remains sparse. They also design exhibits and exhibitions, ensuring the final product is understandable (Henry 2006). Rodari and Xanthoudaki (2005) highlight the variety of skills and roles educators play, as they found educators may also go by titles such as "explainer, pilot, education officer, or demonstrator" (p. 2). One distinction between docent and educator - aside from their pay status - is their educational background. Educators typically require a degree in education, communication, or museum studies. When previewing websites, I noticed some larger science museums might even require a degree with a focus, such as science. There did not appear to be a specific training requirement when working to be an educator, as individual museums determine that need. These individuals most often reported to the Director of Education or Director of Programming, but they frequently report directly to the Executive Director at smaller institutions.

Public Engagement with Science

Public Engagement with Science (PES) is the newest trend within the general domain of science communication. The American Association for the Advancement of Science defines PES as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and public members. Mutual understanding refers to acquiring knowledge and increased familiarity with a breadth of perspectives, frames, and worldviews.

Allum (2010) believes the perfect model of PES would include interactions with science that would allow non-experts (participants) to have the "ability of citizens to read about, comprehend, and express opinions about science" (p. 725). As the importance of a scientifically literate society increases, "researchers and research organizations are being called on to engage with the public as a way to communicate current science" (Selvakumar & Shugart, 2015, p. 14). Chittenden (2011) believes that informal science institutions

> . . . (including science museums, science centers, aquariums, botanical gardens, nature centers, zoos, and planetariums) represents a potentially vast national infrastructure that can bring strong institutional capacities, educational expertise, and communitywide impact to support increased public engagement in current and emerging science (pg. 1550).

PES seeks to bring together those who generate scientific knowledge, those who affect its use, and those who, perhaps unknowingly, experience it in daily life to discuss the social, cultural, and ethical aspects of science. In this way, PES moves beyond serving as a means for transmitting scientific knowledge or an acceptance of scientific authority. Instead, PES activities serve as platforms for discussion and negotiating knowledge to understand issues and make decisions. Chittenden (2009) shared "the learning that occurs in PES can be a complicated process of the scientific, social, cultural, and ethical understanding, resulting in changes in attitude about and knowledge of science, the topic of interest, and one's role in society" (p 23).

While the variety of literature reviewing museum education, educators, and informal learning is vast, it was challenging to locate large amounts of current literature discussing the changes museums have implemented. We know museums have had to change their outreach and engagement procedures with increased technology. I had difficulty finding literature discussing their move to the utilization of different approaches. These literature gaps showed the importance of providing new literature and research in these areas.

Research presented in this chapter shows the growing and ever-evolving field of museum education. There is a growing literature base on informal science educators, but there are still large gaps in the research on their impact on learners. The current literature review focused on the history and nature of museums and museum education, informal science learning, scientific literacy, and museum education departments. The small amount of timely research available on specific positions within museums and how institutions make personnel and programmatic decisions reinforces the significance of this study.

Chapter III. Methodology

This chapter discussed the proposed research questions, the study's nature, information on the key stakeholders to be interviewed and the instrument used, and the specific research procedure. The chapter also included the proposed timeline, data collection strategies, and methods used to analyze it. This study aimed to identify effective science museum education departments and determine shared characteristics and practices.

As addressed in earlier chapters, there is a lack of literature on the nature of “museum educators” serving in informal science learning environments. Bucchi (2008) states it is difficult to predict how a variety of forms of public communication of science emerge because of the variability of the science field.

Research Questions

To define the role museum educators, fill and predict their future roles, I chose the following research questions.

Q1: How do informal science educators view their role within the institution's overall environment?

Q2: What were the responsibilities of individuals in the role of informal science educators?

Q3: How did informal science institutions determine their educational programming's programmatic and outreach focus?

Q4: How did the targeted informal science institutions report communicating science with the public?

Q5: What did these institutions do to ensure they educate the public?

Nature of Study

This study was a qualitative, phenomenological case study. Utilizing the phenomenological approach, my research investigated common trends and themes found through the lived experiences of individuals employed within education departments within informal education institutions. Qualitative research is defined as "a situated activity that locates the observer in the world" (Denzin & Lincoln, 2011, p. 3) and utilizes various data collection methods and sources to draw conclusions and create an interpretation of phenomena in the natural world. Since the study featured cases, I believe qualitative research was the most effective method to analyze data in interviews and observations. Merriam (2009) believes, "Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences" (p.5).

Subjects

The key informants central to this study were drawn from institutions currently employing individuals working in education departments within informal science learning settings (museums, centers, and zoos). Subjects were not limited to a specific institution or job title if their overall responsibilities fall under the category or they were responsible for supervising what we define as 'museum educator.' The case-studies focused on eight main subjects.

Locating Subjects

An exponential non-discriminative purposeful snowball sampling determined the individuals who participated in this study. In this type of snowball sampling, an initial subject provides additional referrals for other individuals who may fit the sample pool (Heckathorn, 2015). Each new subject referred others until a full sample size was located that allowed for data saturation. I utilized individuals in the museum research field who have connections at other institutions to find individuals currently employed as museum educators. I also used a museum consultant recommended by the initial researchers.

Research Procedure

This study was organized as a multi-case study. This design was a more robust inquiry approach (Herriott & Firestone, 1983), with its variety of results being more generalizable than a single-case study (Yin, 2017). Utilizing the multi-case study allowed the researcher to generalize and observe because they can view multiple sets of responses.

First, I sought approval from the Institutional Review Board at the University of Arkansas (IRB). Once approved, I contacted two voices of authority in the informal science education world, John Falk and Lynn Dierking, and asked for their recommendations of organizations that are well-known for quality educational programming in the field of informal science education. After reaching out to eighteen education professionals in the institutions recommended, I located six institutions willing to participate in the study. After the initial response, Falk and Dierking suggested Nik Honeysett, the CEO of Balboa Park Online Collaborative, a museum consultation company in San Diego, CA. Nik in turn recommended three other museums that had a reputation for strong educational departments. Of those three recommended, two responded and agreed to participate in the study. In conclusion, the eight individuals interviewed were all currently employed by the institution they represented.

This interview's findings helped create the operational definition of “museum educator” and ensured the developed survey's validity. Within this survey, I included 7-10 questions about museum educators' meaning, role in the museum environment, organizational structure within the institution, shared practices and procedures, and other trends/predictions found within this field. After creating the survey, I began meeting with the institutions referred to me during the snowball sampling procedure. I completed eight complete case studies with the information found in their interviews.

Once distributed, I gathered data and analyze for trends and similarities. These responses helped narrow down my sample size to the five additional case studies. The science educators completed the Museum Educator Survey (Appendix A). If they held a supervisory role, they also took the Museum Educator Supervisor Survey (Appendix B).

Timeframe of the Study

The review of literature and development of data collection instruments occurred from October to November 2019. I piloted the instrument, finalized the instrument, and applied for IRB from August 2020 to December 2020. I proposed my dissertation, conducted research and transcribed my data from June to October 2020. The data analysis and write up occurred from October 2020 to December 2021.

Data Collection and Analysis

This study used an interview process. Before COVID-19 caused shutdowns, there would have been an observational component to each interview. Bogdan and Taylor (1975) say that the researcher is a split between active participant and passive observer when conducting qualitative research. Patton (1990) reminds us that the “researcher is the instrument” (p. 14) when engaging in qualitative research interviews. Creswell (1997) says the qualitative researcher’s role as an active learner is someone “who can tell the story from a participant's viewpoint rather than just a person who passes judgment on participants” (p. 18).

The interviews followed the semi-structured protocol. There was a set of questions that all participants answered (see Appendix A). The semi-structured protocol allows the researcher to ask candidates to extend their answers and explain their thinking in different ways. The survey questions were written using open-ended phrasing to encourage transparent and full descriptions of job duties, experiences, and attitudes. The interview protocol and schedule are included in Appendix A. The interviews ranged in length from 60 to more than 120 minutes, with the average interview lasting about 95 minutes. After every interview, I transcribed the Zoom video and identifying follow-up questions. All interviews were recorded, and participants completed informed consent before beginning.

Once data was collected, I located short phrases from each research question and placed them in a table. Once in the table, I looked for commonalities between the phrases and used those commonalities to make my themes and conclusions. If there was a phenomenon that was only mentioned by a single institution, I discussed this in Chapter Four, but did not include that as a main conclusion. I utilized the interviews, especially while looking for specific quotes and ideas.

Positionality and Reflexivity

I grew up in a family of scientists. I remembered spending hours in the garage with my father, tinkering away at various experiments as we tried to engage in the science principles we interacted with daily. My family's unique example was the majority of scientists in my family were female. While two of my uncles and my brother were physicists, two of my aunts were also successful scientists in their fields. That example early on led me to my life’s interest. According to the National Science Foundation, while females make up 50% of the college-educated workforce, they only make up 29% of the STEM workforce (NSF, Science & Engineering Indicators, 2016). My family's example for me early on overwhelmed the voices that may have negatively impacted my desire to go into the science field.

Informal science learning holds a place near and dear to my heart because of my childhood experiences. Growing up, my grandfather would bring us to the Minnesota Zoo and the Minnesota Science Museum and I remember spending hours, just transfixed in front of these exhibits and presentations. I loved reading and learning, and museums and science centers appeared to be the best of both worlds. This early interest in informal science centers created a lifelong interest in museums and centers. As an adult, I still spend time visiting these locations around the world as they still hold their same exciting draw.

Working as a teacher positively benefits my research interests because I know what quality education looks like and understand the importance of effective communication as a tool to educate. One area I need to be very aware of is the lack of diversity. While I am a female in a traditionally male-dominated field, I am middle-class and Caucasian. Increasingly in my research experience, my research demographic does not come from a similar background. My experiences with science were positive from an early age. For many individuals, science can be a terrifying and overwhelming topic. My positive experiences as a student interacting with science and frustration towards the lack of quality education can sometimes make it seem as though I am championing a lost cause and not viewing both sides. Additionally, my interest in museums and informal science center provides a positive lens for me to look through.

I feel I am fully entrenched in the transformative framework of research. For me, knowledge is power, and I believe that it can improve the quality of life for people engaging with it. Creswell (2013) believes that “qualitative research should contain an action agenda for reform that may change the lives of participants, the institutions in which they live and work, or even the researchers’ lives” (p. 26).The transformative framework also focuses on a certain level of collaboration and participation from researchers and investigators, which allows the findings to be organic and truthful representations of the phenomena examined.

Notes Regarding the Pilot study

A pilot study was done in early summer with the Director of Evaluation at the Perot Museum in Dallas. This “practice” helped to determine and refine the questions asked in the subsequent interviews and helped identify trends. This initial study allowed me to begin forming conclusions around museum education and its role within the museum infrastructure. After the pilot study was completed, I conducted my first interview at the Perot Museum. After completing three interviews, I determined I needed to ask a few more specific questions, so I added them to the interview and connected with the individuals I had already spoken with about completing a follow-up interview. This longer and more detailed protocol was utilized with the remaining individuals as well.

Chapter IV. Results and Analysis

Introduction and Organization

This chapter featured interviews held with each of the eight identified informal science institution sites. The first section provided an overview of the study participants and then moves to individual case studies representing each of the eight sites. This chapter ended with a cross-case synthesis. Data collected for this study included interview transcripts and follow-up questions. The purpose of this study was to interview selected participants at informal science education institutions, such as museums, zoos, and centers, and identify shared themes and practices held by successful museums. While there is a rich and deep literature on museums, museum education, and information science education, very little has been written about successful education departments' nature and operation within informal science settings. Therefore, this study aimed to identify shared practices of well-known informal science education departments located in science museums, science centers, and zoos.

Overview of Cases: Education in Informal Science Institutions

This overview introduced the subjects and the institutions they represent. All key informants were members of an education team within an informal science institution (zoo, science center, or museum). Everyone interviewed had a different educational and work history, differing years of experience, and held a different position within their institution. The science institutions were in a variety of suburban and urban locations. Even though all agreed to have their identities known, out of an abundance of caution and respect, I assigned pseudonyms that were used throughout the study. Table 1 shares participant names and institution of employment.

Table 1.
Subject Profiles, October 2020

Name	Institution	Job Title
Caitlyn Stephens	Perot Museum	Sr. Manager for School Programs
Raymond Claire	NC Museum of Life and Science	VP of Innovation, Learning, and Engagement
Morgan Rye	Dallas Zoo	Lead Educator
June Gates	Detroit Zoo	Sr. VP of School and Community Partnerships
Robert Graves	Tulsa Discovery Museum	Executive Director/CEO
Esther Park	Michigan Science Center	Outreach Programs Manager
Kirsten Call	Smithsonian National Museum of Natural History	Program Coordinator, Family Programs
Neil Johnson	Smithsonian National Air and Space Museum	On Sight Learning Manager

Case Study Reports

In Chapter 4, I report findings as individual case studies constructed from the interviews, reading, publications, impact reports, and institution websites. Although multiple individuals per site were preferred, for this study, I consider a single individuals response as representative of the institution. Each story includes a brief professional background of each informant. Each case is organized in the following manner. The introduction is an overview of the institutional organization, a summary of tasks, roles, and responsibilities held by educators, information on how they gauge the degree of effectiveness in educating the public, and how assessment drives decision making. Next, the subjects shared information about how they determine programmatic and outreach focus. Then, I included an overview of the individual's interactions with key stakeholders and how they feel stakeholders view their impact—finally, the subject's opinion on effectively communicating science with the public.

While the initial intent was to conduct these interviews in person to include observations, COVID 19 impacted that, so I engaged with subjects through the Zoom platform. After the initial interview was completed, I transcribed the recording and created an initial case study write-up. Once all interviews were done, I scheduled a follow-up interview with each participant, asking any further questions I had. After all case studies were drafted, I shared the individual drafts with the participants and asked for any feedback or changes.

Case 1: The Smithsonian National Museum of Natural History

Kirsten Call Background and Experiences

I was able to contact Kirsten through a mutual connection. When I was able to connect with her, COVID had shut down the museum and majority of the education department had furloughed or reassigned. Kirsten has worked at the Smithsonian National Museum of Natural History for 15 years. She received her BS and MS degrees in environmental science and was working in a lab completing science research for a company when she realized she enjoyed interacting with the public and wanted a more hands-on role in the field of science communication. Because of the interest she developed in science education, Kirsten returned to college and earned a master's in Museum Studies. During that time, she volunteered and interned in the Botany Department at the *National Museum of Natural History*. That experience eventually led to a paid position as an entry-level educator. She was first promoted to the Assistant Director of School and Youth Programming and became the Director position for Family Programs three years ago.

Smithsonian National Museum of Natural History (NMNH) History and Overview

The Smithsonian is one of the most well-known museums in the world. The Smithsonian was created with funds left from James Smithson, who left his estate to the United States upon his death, with the specifications that the money be used to “found at Washington, under the name of Smithsonian Institution, an establishment for the increase and diffusion of knowledge (A Brief History). After leaving his estate, it would take ten additional years before Congress would authorize an acceptance of Smithson’s estate. While the Smithsonian was founded in 1846, the National Natural History Museum (NNHM) opened its doors on March 17, 1910, and was home to art, culture, history, and natural history collections. (Smithsonian, 2019). The NNHM was created with funds appropriated to the Smithsonian from Congress based off work being done by William Henry Holmes, a Curator at the National Museum. Spencer Baird, the first curator of the National Musuem oversaw the creation of the NNHM. The museum's first collections included artifacts from America's early days of exploration and the American West. Quickly, the museum outgrew its facility and pled to the Board of Regents to provide funding for a third building. In January 1903, US Congress appropriated money to the Smithsonian for new construction. On August 11, 1909, employees began to move into the new facilities and transfer collections. By this point, the museum housed over 10 million objects. The new building opened to the public in March 1910, while construction was not completed until June 1911.

During World War One, the Bureau of War Risk took over the building, this meant that the museum was closed to the public from 1917 to 1919. The U.S. National Museum moved to create two divisions in 1957: The Museum of Natural History (MNH) and the Museum of History and Technology. These new classifications started the collections' movement, history collections moved to the National Museum of American History, and art and portraits relocated to the newly created American Art and Portrait Galleries which opened in 1968. Expanding the original building was approved in 1930, but funding was not provided until 30 years later, in May 1960. That phase of construction was completed by 1965 and delivered three additional floors. In March 1969, the Museum of Natural History was renamed the National Museum of Natural History better to reflect their connections to anthropology and national history collections. In the 1980s, the concern for space prompted the development of a collections storage area along with conservation and office space to open the Museum Support Center in Suitland, Maryland called the Museum Support Center. The National Museum of Natural History currently oversees around 145 million artifacts and specimens, split between their main campus at the National Mall and the Museum Support Center.

In 2016, the museum released three priorities for focus over the next five years. The goals included accelerating discoveries about planet Earth through fieldwork, collections and research, inspiring people to understand and seek out scientific learning and improving partnerships inside and outside the institution (pgs. 6-11). These priorities guide the budget and programmatic decisions the museum makes. Goal 2 is especially important for the education department as it directly speaks to their impact.

Washington D.C is home to over 70 museums. The National Natural History Museum is a part of the Smithsonian network, which has eleven museums and galleries on the National Mall property and six other museums, and a National Zoo in a nearby neighborhood.

Administration. Due to the National Museum of Natural History's size, the administrative team is more extensive than seen at most facilities. The executive team titles are in the table below. Additionally, the museum employs over 450 individuals in the science department, including scientists, research associates, pre-and post-doctoral fellows, and scientists affiliated with other agencies. The scientists are separated between eight contents: anthropology, botany, entomology, invertebrate zoology, mineral sciences, paleobiology, vertebrate zoology, and marine biology, which also happen to be the museums current research focus. The current advisory board is made up of 27 members.

The National Museum of Natural History employs over 450 individuals within their science department, including scientists, researchers, and post-doctoral students. The science departments found within the NNHM are in the table below.

Institutional Organization of National Museum of Natural History

Because the National Museum of Natural History is a federally funded facility under the Smithsonian umbrella, the directors report to CEOs over the entire museum family. Kirsten works directly under the Director of Education at the museum. Under that director are three Assistant Directors: Learning Venues and Visitor Experiences, Community Programs and Content, Strategy and Science Education. The Learning Venues and Visitor Experiences department include volunteers, an information desk, learning spaces (specific places within the gallery), an insect zoo, and a butterfly garden. The learning spaces house a variety of exhibits and displays over a variety of topics. At the time of this interview, the museum was closed due to COVID 19 and the entire facility was being renovated. The community programs director oversees Family Programs, Youth Programs, School Programs, and adult programs. The Content, Strategy, and Science Education director oversees distance learning and liaises between exhibit creators and museum scientists

Kirsten Call described the three departments as being space-focused (learning venues), visitor-focused (community programs), and science-focused (content and strategy). She mentioned that because the museum was so large, it was naturally much more segmented than other informal science learning facilities. Entry-level educators are utilized throughout each department. The Assistant Director of Education, who is Gale's boss, reports to the Deputy Director of the National Museum of Natural History. In turn, that individual reports to the CEO of the Smithsonian complex of museums. Due to the museum's size, Kirsten does not often interact with individuals higher than the Assistant Director of Education. When COVID impacted the museums ability to conduct outreach opportunities, many of the educators were temporarily reassigned to other departments, including exhibitions and renovations.

Organizational structures impact. Call shared the museum is very educationally focused. "All departments within the institution have the expectation they will support education and the programs we are doing. Often, it is a facility need or resource we need created." At the end of the day, Kirsten stated, everything should serve the museums mission.

> We all work together to support the mission and vision of the museum. Other departments don't hesitate to check us if our work isn't aligned with what we are supposed to be doing. We are all in this together. While people take care of us, we, as an education department, take care of them. They don't come to see how clean the building is, but we want them to leave thinking man, the building was clean.

Programmatic and Educational Offerings

The programmatic offerings at the Smithsonian are vast. Due to the museum's size and reputation, they receive large numbers of visitors each year. When speaking with Call, the institution works hard to guarantee visitors have the option for a plethora of educational opportunities. The list below are the most popular program areas the Smithsonian has, according to Call.

Live Video Programming allows educators to zoom with groups of students and provide a presentation on a predetermined topic. These zoom presentations are recorded for access later.

School Programs were offered daily. These presentations are led by museum educators and utilize science processing skills to learn new information. Some of the program topics include animal adaptations, discovering dinosaurs, insect survival, urban habitats, climate change, and food systems.

Youth Programming offers a variety of options for youth. From a short video series discussing current scientific topics to internships for teenagers local to the DC area, the museum has something for almost everyone! They also offer after-school programs, including behind-the-scenes tours and interactive opportunities.

Before COVID, the museum offered in-person family programs which covered a range of topics and used hands-on experiences to teach new scientific content. During COVID-19, the museum provides videos with read aloud’s and skill-building activities that allow them to learn about the natural world around them and collections found within the museum.

Evening and Weekend Programs, sometimes called *Science Café*, provide visitors with an opportunity to interact with museum staff and special guests through a variety of topics and formats. Individuals may be afforded a behind-the-scenes look at science currently happening at the institution.

Natural History Summer Explorations were free virtual summer program for students in 3-7th grade covers various natural history topics through a daily webinar, videos, activities, and projects. Students will interact with scientists and educators employed within the museum and by various other institutions around the country.

Before COVID-19, the museum offered weekly professional development opportunities for teachers covering various science topics and highlighting ways to use the museum's resources.

Tasks, Roles, and Responsibilities of Educators at NMNH

Within the NMNH family, educators play a variety of roles. In this facility, educators are responsible for designing and evaluating programs offered. They do this by collaborating with other educators within the institution and other employees, including scientists and researchers. The National Museum of Natural History prides itself on utilizing current research in the museum to drive programming. This happens through the utilization of on-site scientists who aid in idea generation and provide research for exhibits and programs. Evaluation happens during and after programs and lab experiences. Kirsten shared the view that the most manageable group to evaluate is schoolteachers because they understand the importance of assessment. Admittedly, Kirsten shared, this step is also one of their weaker ones because the museum is so large and receives many visitors every day, so tracking them and asking their opinions can be challenging. According to Call, assessment is not an institutional priority, but many educators believe it should be an increased focus.

Museum educators at NMNH are also the liaisons between the science staff (scientists researching within the Smithsonian and the public). As not every institution employs scientists in house, this role is vital in ensuring the education department understands the research being utilized. The Bone Hall exhibit is a great example of this partnership. While educators built and created the exhibition, they leaned heavily on scientists within the museum to ensure accuracy. They work to share the research done in real-time with Smithsonian visitors using interactive displays, live programs, and floor interactions. Educators also ensure visitors find relevancy in the shared content through guiding questions and short discussions. As part of the Smithsonian’s mission, they want people to understand the natural world around them and their place in it. They accomplish this goal by actively working to tie new learning to the individual guest's own life.

The Smithsonian Museum of Natural History is collections-based (objects-based), so educators work to incorporate collections into the learning experience. This happens by creating programs around a particular object or collection. They may also circulate the floor with an item that could spark interest. Kirsten shared the museum has worked to increase its online offerings in the past decade to reach visitors who may not ever be in Washington D.C.

Educators also play an essential role in the museum's day-to-day success by setting up and tearing down programs and providing programs for schools, youth, families, and ordering supplies, according to Call. The museum has an internship program that facilitates additional support for educators through the form of professional development. With the museum's closure due to COVID-19, educators had to rework how they approached learning. They filmed webinars and presentations and offered digital school programs and online exhibits. One thing they worked to create content for quickly was COVID-19. “We know that the whole world is currently trying to figure out what COVID-19 is and how it's going to impact the world. Our goal was to create content, along with the scientists on our staff, that shared real-time information on the topic” Call shared. Within the family programs education department, there are two specific groups of people: facilitators and “faciliziners,” a term coined by Call. The “faciliziners” are responsible for creating and designing programs

Educators View on their Role within the Museum

Educators view themselves as audience advocates shared Call. They know their role ensures science is brought out from “behind the scenes” and made accessible to the consumer. Due to scientists' employment within the facility, they play the vital role of the conduit between science and the public. Making complex scientific information understandable is one of their most important job responsibilities. “There are times when an educator can explain a challenging science concept much more clearly than a scientist or researcher who may not have an appropriate vocabulary," Call stated.

Several years ago, the NNHM began to create various hands-on and interactive experiences throughout the facility. Q?rius (pronounced curious) is one of the most well-visited hands-on spaces in the facility shared Gale. In this interactive space, educators worked to bring together the scientists, researchers, and collections currently located in the institution. In this space, visitors can use microscopes, interact with more than 6,000 collection objects, solve puzzles, and meet with scientists. The main Q?rius space is separated into Q?rius and Q?rius Jr., which offers activities appropriate for younger children. Kirsten shared a story about a little girl whose family came to the museum and spent the entire day in the space. "That's when I realized what we're doing was 'successful.' It's hard to conduct an appropriate evaluation for such flexible spacing but seeing someone spend an entire day in the space was evidence that we had accomplished something."

Perspectives of Commonalities Between Educators

Most of the career museum educators started as independent contractors at the National Natural History Museum shared Call. Individuals with experience interning or volunteering within the Smithsonian network will also be given priority when interviewing. The museum does not require a formal background in science or science education but instead values enthusiasm and experience engaging an audience. According to Gale, "we can always teach content, but we cannot teach passion." While a basic understanding of the scientific process is advantageous, it is not the primary determinant in hiring educators. "Educators need to possess all of the people skills. They interact with the public almost daily and scientists and researchers. We have to be flexible and able to go with the flow, but also prepared to answer questions or demonstrate something at a moment's notice," stated Call. Kirsten mentioned that what was unique to their museum was confidence in working with scientists. She said scientists could be challenging to collaborate with and understand, so having a skillset to make the complicated understandable is incredibly important. "There are two types of scientists we interact with: those that can explain what they are thinking, and those that cannot, for the life of them, make complex topics more understandable. We have to know enough about what current science is happening to bridge the gap and build meaning."

Gauging Effectiveness in Educating the Public

When the museum works on creating a new exhibit or program, they work to answer the question, "What change do we want to impact with this audience?' Once that is determined, they use the answer to help create a plan to measure that impact. Every evaluation includes questions about interest, knowledge, attitudes, behavior, and 21^{st}-century skills, which include creativity, collaboration, and innovative thinking. Once these assessments are created, they disperse them to individuals after a program or exhibit experience. Kirsten mentioned that schools are the best at responding to evaluations. "We don't always know what is going to work. We work to have a good understanding of what the word 'fun' is, but sometimes we miss it." Evaluations and staff stories tend to provide enough information to allow for adjustments.

The National Natural History Museum is currently working as a partner on the Informal Science Education Evaluation (ISEE) through a National Science Foundation grant. This assessment will be used by any informal science education program offered throughout the museum and is currently being created through a collaboration between the museum educators and NSF staff. The project is working to create a framework to guide thinking about intended outcomes, aspirational outcomes, and what happened post-experience. The museum plans an

April 2021 conference to receive feedback before publicizing its evaluation. "We know that evaluation is a weak spot in what we do. We must improve in that area because we are increasingly being asked to justify decisions we make, whether funding or program based. Evaluation justifies what we are doing or helps us redirect to ensure we are successful in the future.

The museum offers assessments and evaluations in several ways. Kirsten shared the museum is always looking for ways to gather meaningful data. “We don’t want frustrating surveys because that always leads to bad feedback.” The museum utilizes picture emojis for children’s feedback. They ask them to point at the emoji that best represents their feeling or attitude towards an experience. The museum works to stay away from longitudinal studies, as they have found the information doesn’t impact their work. By the time the study was done, the practice had been changed so the evaluation wasn’t necessary. The museum instead focuses on attitudes and experiences. If a guest takes an online class through the museum, they receive an email with a survey immediately following the class. There are iPads throughout the museum with short questions about exhibits and programs, often requiring just a yes or no. Every person who buys a ticket on sight also receives an email with an evaluation at the end. These methods are all used to gather small data sets that can be used to guide and change programs and experiences throughout the institution.

Effectively Communicating Science with the Public. Allowing people to investigate and make their conclusions was the key to effectively communicating science with the public. She expressed the view that science museums had a responsibility to provide

> . . . hands-on and interactive science experiences that were contextualized in a way that made sense to their world. Science must be contextualized in a way that makes sense to the person’s world. It can’t just be this static thing right in front of

them. They can't just walk in and walk out of a museum. To be sticky or memorable, it must be in a context that makes sense to them.

The other responsibility informal science educators must communicate science with the public effectively is finding a way to make it stick. According to Gale, "situational interest has to make the transfer to maintained interest to make a change." Kirsten also feels strongly that the museum provides opportunities for people who struggle with science, for even a moment "Our job is to model how people can best figure things out on their own. By providing resources and experiences, we want them to do the work. Our job is to assist in the process, but not to do the heavy lifting."

Building Programs and Outreach

There are several ways the National Museum of Natural History determines its programming and outreach focus. One is to look directly at the research currently being conducted by museum scientists. The museum also tries to focus on the scientific process laid out in the UC Berkley Understanding the Process of Science framework according to Call. The framework is found below in Figure 1.

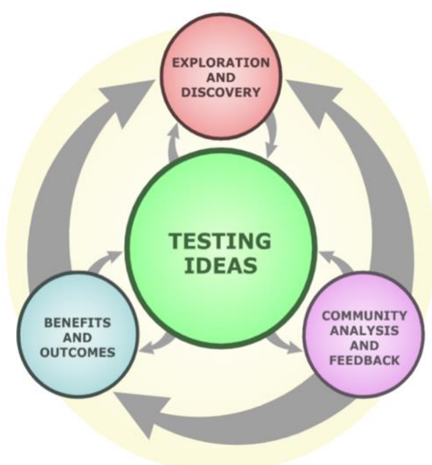

Figure 1.
*Understanding the Process of Science Framework (*Understanding Science, 2021*).*

This model is based on the understanding that science is a dynamic, non-linear process. There are four categories: testing ideas, benefits and outcomes, community analysis and feedback, and exploration and discovery (The Understanding of Science). Scientists move between these activities in various ways, never taking the same path. Some of these activities can be seen in Table 2:

Table 2.
Understanding the Process of Science Model

Testing Ideas	Benefits and Outcomes	Community Analysis & Feedback	Exploration & Discovery
Gathering data	Develop technology	Feedback and peer review	Making observations
Interpreting data	Address societal issues	Replication	Asking questions
	Build knowledge	Discussion with colleagues	Sharing data and ideas
	Inform policy	Publication	Finding inspiration
	Satisfy curiosity		Exploring literature
	Solve everyday problems		

Using this model, the museum allows visitors to pass between categories on the continuum through various educational offerings and exposure to them in places like Q?rios. The educators ensure this is possible by creating opportunities for individuals to drive their own thinking and research and staffing the area with individuals who can help answer questions. In the space, visitors can use microscopes, touch over 6000 items form their collections, and even meet a scientist.

Whatever the experience created, the museum wants visitors to "live the process of science" as they engage an exhibit space. As the museum is collections-based, Kirsten believes they are responsible for highlighting the museum's collections. The educators work to draw visitors back to the question, “how does this object help me understand the world?” When determining programmatic and outreach goals, the last primary focus is to show representation in science through diversity and perspectives. Kirsten feels it is imperative museums discuss current events from a non-biased lens and work to ensure different perspectives find a safe space. While educators are designing programs to reinforce what visitors might learn naturally, the museum doesn’t work to tie anything to a specific set of standards or curriculum. “We work to align our curricula to ensure continuity across the floor, but we work to design with local students in mind first. We want to be rooted in curricula without being rooted in curricula you may only see in the traditional classroom.” Creativity plays a massively important role in the design and implementation process at the museum.

> Each science center or museum covers similar topics. Our name doesn’t get us a free pass. We have to work to constantly find new ways to teach old ideas. Because of the influx of virtual outreaches, we have another area to compete with. That adds to the challenge of what we are doing. There is always this invisible pressure to be the best.

Role of Informal Science Facilities

Informal science venues should be viewed as community centers. According to Call, “when people enter our space, they should feel safe, and when they leave, they should want to come back.” These unique places should provide safe spaces for meaningful conversations about the world around them. The museum also has a responsibility to listen to the people in its community and the world around them. Call feels her staff best does this through authentic engagements with visitors. “Ask them a question! You learn all sorts of things.” she shared. Kirsten stated,

> Museums are responsible for addressing the big topics happening in the world around them. Climate change, for example, is an important topic we should be talking about. And not only trying to actively find ways to fight the fatigue or the doubters, but also finding a way not to shame people who disagree. In a sense, we are just the conveners.

Informal science institutions also provide a safe space for visitors to interact with science, a topic that may have previously been scary or intimidating. “When we can provide someone a positive experience with science, in that they leave and say ‘that was fun, we know we have been successful. It is not always about learning lots of things. Sometimes it is just about having a positive experience.”

Case 2: The Tulsa Discovery Lab

Robert Graves Background and Experiences

My key informant at the institution was Robert Graves the inaugural CEO for the Tulsa Discovery Lab. Before assuming this position, he earned a Ph.D. in Physics and always had a great interest in science. While working on his Ph.D., his wife began working for a traveling science project in Missouri and Robert constructed exhibits for the program and eventually began traveling with the project. As the project came to an end, Raymond became the Bootheel Youth Museum executive director in Missouri. In 1998, Raymond assumed a leadership position within the education department at the Oregon Museum of Science and Industry (OMSI) and spent fifteen years there. The Tulsa Museum reached out about starting a hands-on science center, and the Discovery Lab was born. Raymond transitioned to Tulsa to take over as the museum's inaugural CEO. Due to the centers' smaller size, there were not many individuals available to interview, and because of COVID19, most entry-level educators were furloughed.

Dr. Graves believes you see an emergence of “STEM ecosystems,” which are centers that house more than one informal science experience. Tulsa, for example, has not only a science center but also houses a zoo and aquarium. He believes that informal science experiences should also connect to everyday science in our lives. “Drawing people's attention to the daily role science plays in their lives makes it more important,” Graves states. Graves also said that most STEM learning doesn’t come from a classroom (95% of experiences are outside formal education settings). Science centers have a unique opportunity to breed excitement and interest that could last a lifetime. In the perfect world, Claire believes that science museums could impact how science is taught in formal classroom settings, highlighting the importance of hands-on opportunities to learners.

Tulsa Discovery Lab History and Overview

The Discovery Lab was started in 2007 as a traveling museum. They would visit local schools and do short scientific demonstrations. In May 2013, the museum opened its facility. In the winter of 2020, the museum broke ground on a 50,000 square foot facility in The Gathering Place in Tulsa, OK, an outdoor entertainment venue. The Discovery Lab provides outreach museum classes to area schools and organizations and hosts over 20,000 students yearly for field trips. The museum's financial aid program pays around 25% of all tickets and 40% of the school-based fees.

The Tulsa Discovery Lab (TDL) leadership is overseen by Robert Graves, the Director, and CEO who supervises Directors of Organizational Development, Education, and Exhibits. The Discover Lab is governed by a Board with 19 Directors. In the lab, visitors will experience a variety of interactive exhibits, tailored to specific ages. In addition to the main hall, visitors can take small classes in “The Workshop” or bring younger visitors to a toddler specific area, which features a variety of developmentally appropriate activities.

Oklahoma has 13 accredited museums in total but is home to over 500 museums. According to the Oklahoma Museum Association, there are 27 National History and Natural Science museums, ten science and technology museums, and five zoos and aquariums. Tulsa is home to several museums, including the Tulsa Air and Space Museum, an aquarium, and the Tulsa Zoo.

Institutional Organization of the Tulsa Discovery Lab

Under Graves as CEO, the museum has several “middle management” roles, a Director of Organizational Development, a Director of Education, and a Director of Exhibits. Under the Director of Education is an Education Manager. Under the Education, manager falls the educators and some exhibit designers. For this study's purpose, I could not speak with the director of education or educators due to COVID furloughs and availability.

The museum vacillates between having educators with a specialized responsibility and educators who perform any role necessary. When educators were responsible for a specialized education component, a few of the specialties were school programs, site-based programs, and special events. Graves found they prefer educators who can take on any responsibility, ensuring they are always prepared. “When individuals are asked a question, I don’t have to wait for them to go find someone who knows the answer. The entire staff should know the answer.” Being the largest STEM outreach center in Oklahoma, Graves shared, the museum staffs several educators and provided programming for a large region within the state.

Programmatic and Educational Offerings

The TDL website highlights the variety of programs offered at the Discovery Lab. Besides regular visitors and members, the museum offers various educational programs outside of the Discovery Lab.

TDL offers clubs throughout the school year for children pre-k through sixth grade. These camps provide hands-on activities and teach a variety of science content. They also provide field trip opportunities for small groups to class sizes and affords interactive experiences with museum exhibits and activities. TDL provides hands-on opportunities for after-school programs or classrooms. These programs, led by the museum educators, are offered with a field trip or individual experience. This hands-on STEAM programming is tailored to specific ages and interests and is taught through a class setting using hands-on activities and science education. A few examples of the STEAM offerings include Active Anatomy, Hear, Hear!, and Germ Detectives.

The *Accessible Discovery* (AD) program was created to help increase underserved students' access and participation. Organizations that participate in AD are offered an outreach class and a museum experience. The museum partners with Tulsa Housing Authority, the Department of Human Services, Family & Children's Services (Women in Recovery program and Parenting in Jail program), Sooner Start, Educare, and the YMCA of Greater Tulsa.

Tasks, Roles, and Responsibilities of Educators

Graves said the primary identity of the education department should be outreach. Educators within their institution have four main functions: Curriculum Development, Lesson Delivery, Museum Classes, and Lab Space Facilitators. Curriculum development encompassed creating the curriculum and lessons used by the camps hosted by the museum, field trips, and classes and outreach. Those individuals do. Those individuals do not have to be certified teachers, but they do have a deep understanding of Oklahoma's state standards and expectations. The educators are also responsible for lesson delivery, both on-sight and off-sight. The center provides assemblies and demonstrations for area schools, so educators frequently find themselves moving between the center and local organizations quite frequently. Museum classes encompass their birth through sixth-grade programming. Museum educators teach classes and include hands-on components to teach the STEM material. Sample class titles include Active Anatomy, Germ Detectives, The Science of Seasons, and Brain Games. Finally, educators facilitate all learning in the lab spaces. These areas are inquiry-based and highly flexible, allowing visitors to choose what exhibits they visit.

The educators work with local schools to develop standards-based outreach opportunities. Schools or student groups may choose between the same classes offered at the center's site. Also, they offer engineering design challenges. One thing the center works hard to do is to provide standards to every class. “We want to be attractive to teachers and including the standard(s) a class covers provides the additional justification they may need.” Because the same educators create the programs that provide the in-class instruction, it makes the transition between responsibilities seamless. During the 2018-2019 school year, the museum saw over 20,000 students off-site. While outreach is a massive focus of the education department, they also are responsible for creating interactive and engaging museum-based classes and programs. Finally, educators are responsible for the “high facilitation areas.” These areas are project-based and cover a variety of scientific topics. The museum has a combination of guided and open-ended inquiry spaces, both of which educators are responsible,

Perspectives of Commonalities Between Educators

There are several shared characteristics the Discovery Lab looks for when hiring educators. The Discovery Lab was the only museum that referenced they request a degree in science or education, but they do not feel better about one than the other. Even more important than a degree in science, Graves feels a stage presence and charismatic presence are vital to a successful educator. “A person who can draw individuals in and keep their attention is important for our success. You have to be able to command attention from the start.” Raymond states that classroom management skills and confidence in their STEM content knowledge make it easier for educators to successfully draw in and maintain an audience but suggests that those skills can be taught. They also look for individuals who seem interesting or entertaining in the interview. “If they can entertain a dry interview committee, they can entertain a visitor at the museum.”

One thing Raymond said that I did not hear from others was the importance of an individual's willingness and ability to say, “I don’t know.” Graves says, “I don’t want people to feel they have to make up an answer if they don’t know something. Part of modeling the process of science is sharing 'I don't know, but this is how I can find out.'" Graves is proud of the collaboration between educators on staff and feels they support each other, but especially newcomers, in a way that makes them an effective educator.

Gauging Effectiveness in Educating the Public

According to Graves, the museum does not have a specific director of assessment and evaluation, but they do have a director responsible for evaluation and visitor studies. Over the last few years, the museum began utilizing the Harvard PEAR Common Instrument, which allowed them additional resources and training to evaluate science-related attitudes and experiences. The Harvard PEAR Common Instrument Suite (CIS) (Figure 2) is a self-reporting survey that measures a variety of science attitudes. See below for an overview on what the PEAR CIS is.

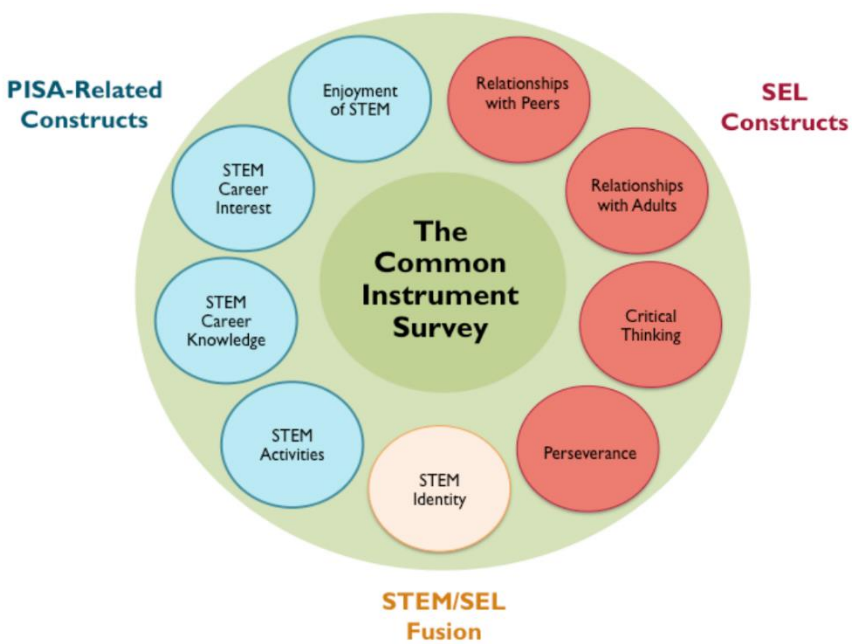

Figure 2.
Harvard PEAR Assessment Model.

Because the program was so valuable, the museum staff became PEAR evaluators, enabling them to assess and provide feedback to other programs in the area. Graves stated they have a high evaluation response rate due to their education team's many site visits yearly. He believes people are more willing to provide feedback when they feel connected to the work you are doing. The museum is also working to offer post-experience surveys that allow for reflection space.

In addition to the use of the PEAR Instrument, the center does require directors to participate in evaluations and visitor studies. “Educators, because they are certified PEAR evaluators, seem more confident in asking questions and dialoguing with guests about what they learned and why it was important.” Graves shared they are working to making evaluations a more natural part of the process to ensure they happen more frequently. Individuals participating in paid programming seem more willing to participate in a post-program evaluation, Graves shared. They also closely monitor bookings and reservations. “If we have a program that is only consistently requested one or two times a year, we are more likely to move away from that program and try something new. In taking recommendations, Graves shared they look at the activity of the recommender to determine their next steps.

> If an active user of our facility recommends a change, we will always at least consider it. They may say something like ‘In Oklahoma, third graders are learning about Earth Science. Could you create something on that topic? If we know the topic will be popular; we will consider it. We also respond to solicitations for funding. If a particular funding has an interest in a topic, we will respond if it fits our work.

Effectively Communicating Science to the Public. Dr. Graves believes the primary key to effectively communicating science to the public is meeting them where they are. According to him, “social media has changed how we interact with individuals in a major way. Social media is flashier than once-flat outreach, so we have to work to maintain their interest a bit harder.” He also believes if visitors have a positive experience, not only are they more likely to return to the museum, but they are more likely to bring their friends. The organization also heavily relies on surveys and evaluations as tools to ensure individuals are not only enjoying their experience, but also learning information. At the end of the day, if we have good products and services, people are more willing to return to the space again. Ensuring there is content that is both relative and accessible is huge in meeting people where they are. We never want a visitor to leave feeling defeated or stupid. If that happens, we haven't done our jobs. People should leave our space re-energized and passionate about science in the world around them.

Building Programs and Outreach

The Discovery Lab uses four methods to determine future programming and outreach focus: staff enthusiasm, stakeholders' reflections, programs that are often getting booked, and responses to funder and donor requests. The Lab has a program called 'Project Strategy'. Any staff member invited to join the program and able to suggest themes or topics they should cover in the future. Dr. Graves encourages the education staff to share current science topics that are of interest to them that may find a good home in the center. "If our staff are passionate about it, they are going to do a great job facilitating it," Graves states. They also view feedback and bookings as valuable data to drive further ventures. "If a program on rocks and minerals gets booked quickly consistently, we may look to add additional experiences in that lane." Feedback from visitors and schools drives change in current programs and future programs. Finally, donors and funders play a vital role in future programming. When funders have interest in a specific topic, especially if they are willing to pay for it, "we will make a place for it," Graves said. When board members or individuals in the community offer grants, Graves stated the museum always tries to find a space to add or make changes to meet the requirements. Because they are privately funded, museum grants and donor money can make all the difference. Yearly, the Lab also invites all stakeholders and donors to a year in review meeting. At this meeting, they will request not only feedback, but also suggestions for the following year.

Role of Informal Science Facilities

Graves believes informal science facilities are a vital part of the learning landscape of any community. "We are beginning to see the emergence of STEM ecosystems which appears to be an attempt to coordinate all STEM providers to create a more cohesive impact on the community." In Tulsa, there is a regional STEM alliance in which the lab is a member. The goal of the alliance is to connect formal and informal educators and the myriad of museums and centers. Graves shared "This connection has inspired other informal learning centers, such as the art museum, to work on including STEM where possible. Even the history museum in town is trying to incorporate STEM!" He believes the more science facilities can work together, especially those geographically close to the next, the greater the good they can do for their community. "Studies show most science is not learned in the classroom, but rather through informal experiences. We are here to provide just that."

Case 3: The Detroit Zoo

June Gates: Background and Experiences

June Gates is the Chief Program Officer at the Detroit Zoo. June spent ten years in retail before volunteering at the California Science Center. While the job was interesting to her, June realized she should return to college to begin taking classes to become a teacher. While in college, she found out about emergency credentialing. When she approached the museum about leaving to become a teacher, they offered her a higher-paying job. During her time at the museum, she created a program reaching out to minority kids in the community who lived in low-income housing. Eventually, her partnership became a program called the Kids Curator Club. This club targeted high-needs, low-income high schoolers to the museum. June had noticed that kids would come to hang out at the museum in the evenings and on weekends, so she decided to create a program. Members of the club would come to the museum every night and get help on homework, volunteer, or take classes. Through a grant, she could fund the program for six years. The program became so well-known, June recalls parents calling to request her to waive the age requirement so their younger children could join.

The grant allowed for lots of professional development, which allowed her to network. The program flourished and became famous and afforded her a chance to meet with professionals across the field. June eventually ended up in St. Louis, where she started the same program at the St. Louis Science Center. A close colleague recommended the Detroit Zoo and received the job. June describes herself as a team player and says her employees know they can come to her with ideas at any time. She says, “in our role, there are always power dynamics. I want my staff's opinion. I want them to challenge me.” That relationship has allowed the education department to flourish and become very successful.

June believes informal science plays a massive role in engaging individuals to be more actively involved in the civics of the world around them. “Aside from science centers, museums, or zoos being fun places where you can come to learn something, I think we have a responsibility to ignite interest in current events around us in the hopes people get more involved.” According to Miller, zoos also show the beauty of the natural world and the importance of preserving that world for future generations. “Modeling how to care for life around you actively can echo into generations to come.”

Detroit Zoo History and Overview

The Detroit Zoo began in 1883 when the William Cameron Coup circus came to town and quickly went bankrupt. Luther Beecher, a local businessman, financed the animals' purchase and had a building built to house them called the Detroit Zoological Garden. The zoo lasted one year before closing. In 1911, the Detroit Zoological Society was founded, but the new zoo did not open until August 1, 1928. During the opening ceremony, the mayor was almost attacked by a polar bear! By 1930, exhibits were constructed across the property, including a bear's den, sheep rock, birdhouse, and elk exhibit. The Detroit Zoo was also the first zoo in America designed with all cage-less displays.

With the Great Depression came a pause on all expansion and projects, but they resumed in the 1940s and continued to expand over the next decades. The 1980s brought about a change for the zoo, as they began to charge an admission fee for the first time and stopped all programming that contained performing animals at the insistence of animal rights activists. The zoo also made headlines in 2005 when they sent both their elephants to an elephant sanctuary in San Andreas, California, stating that harsh Michigan winters were unfair to the animals. In 2006, the Detroit City Council voted to shut the museum down as a part of city-wide budget cuts. After a massive public uproar, the city passed ownership to the Detroit Zoological Society along with a $4 million grant from the state of Michigan. Sitting on over 125 acres of exhibits, the zoo is home to more than 2,400 animals belonging to 235 species. Michigan is home to 13 informal science centers, with Detroit having the Detroit Zoo and the Michigan Science Center.

Institutional Organization of the Detroit Zoo

According to the Detroit Zoo website, the zoo has five chief staff: Executive Director and Chief Executive Officer, Chief Life Sciences Officer, Chief Operating Officer, Chief Program Officer, and Chief Development Officer. The department of education is the responsibility of the Chief Program Officer. They have 74 active members on their board. Before COVID-19, the zoo had 261 full-time and 30 part-time employees and 1,100 volunteers.

The Detroit Zoo is a part of the Detroit Zoological Society with a small site in downtown Detroit and a larger, 125-acre zoo in the suburbs. The Detroit Zoo has been around for over 125 years and has a board of 65 individuals. The zoo has a CEO and then five Chief officers. Under the officers are nineteen directors. June feels "the education department is responsible for communicating the institution's mission. We are not responsible for making money for the institution."

June Gates's main areas of responsibility are education and volunteers. During the explanation of duties, June shared a Vice President over Education before her arrival. While under that person's leadership, education fell under operations. When June arrived at the zoo, the board shared that part of their strategic five-year plan was for education to be part of the institution's core mission, so they realigned to support that goal. The realignment shuffled individuals into more specific departments, adding a director of Education and formalizing the zoo's educational process. "Once education had its own space, it suddenly had a seat at the table.

What was previously seen as just an IMAX Theater and a simulation ride suddenly became a department full of people with great ideas."

Organizational Structures Impact. Gates is the Chief Program Officer of programs at the Zoo, so she is an important voice in the direction the zoo takes. According to Gates, the education department is responsible for communicating the zoo's mission. They are not responsible for making money. The education department has an important voice in what the zoo does and is well respected by other teams. "Individuals in other departments know the educators work hard and put in the time to make their programs a success. They are a voice that people want to hear."

Programmatic and Educational Offerings

According to the institution's website, there are various educational offerings for visitors and field trips alike. The virtual offerings below had been offered in some form in-person prior to COVID.

Throughout the *Virtual Ventures Program,* students complete a self-paced virtual program that includes interviews with field experts, hands-on activities, videos, and more. Topics covered include conservation, careers in zoology, and animals found in our neighborhoods.

Due to COVID 19, the zoo provides virtual field trips, including learning labs, a virtual map to explore, and in-class activity.

The zoo offers various professional development opportunities on topics ranging from utilizing children's literature to cover scientific topics, conservation education, creating outdoor classrooms, and more.

Other programs the zoo has include opportunities for outside groups, such as the Boy or Girl Scouts, to earn badges. They host camps where children learn about animal care and welfare and a variety of other fun family activities.

Tasks, Roles, and Responsibilities of Educators

Educators at the Detroit Zoo play a variety of roles. June replied, “2 years to 90 years,” when asked about the education department's target audience. The educators within the department share a variety of responsibilities. One of their primary roles is working with schools on various learning opportunities and experiences. June reported that educators work closely with schools to ensure they are creating programs that address the necessary science learning standards. “We want the teacher to know we aren’t going to waste their time. Providing standards shows them exactly how their time is going to be spent.” These standards show what content area and processing skills may be covered during a class or field trip.

Detroit Zoo educators also provide professional development for teachers, teaching them how to utilize the zoo's resources and teaching them new information. They are responsible for determining supplies and materials needed to keep programming moving forward. One unique thing museum that educators are responsible for is facilitating science communication workshops. In these workshops, educators train scientists on effectively sharing the results of their research with the public. These workshops train scientists how to more clearly describe their research when sharing with the public and then provides them a chance to practice with zoo visitors. The Detroit Zoological Society offers a Fellowship in Science Communication through the Portal to the Public Program. Fellows attend three workshops and work with zoo staff to learn exciting and engaging ways to share their scientific work, including the creation of hands-on activities. Examples of researched topics include bat ecology and legume nodulation. June mentioned she found so many scientists did not have the skills to effectively share their work in a way that was understandable to the public. “Our goal is to help them ‘unlearn’ science talk and learn how to be engaging and accessible to every audience.”

Educators View on their Roles and Responsibilities

The educators within the zoo are responsible for working with schools and other educational groups. They create learning experiences surrounding standards for local schools. Once the programs are created, the zoos educators are responsible for delivering the programs. They also work with pre-school aged children, teachers, and senior citizens. Another unique responsibility for educators at this institution are the science communication workshops they hold for the public. Individuals, normally ones with science backgrounds, jobs, or degrees, attend these workshops and learn how to effectively deliver information. Once they have gone through several workshops, they set up their presentations outside at the zoo and practice communicating their science with the public. This is one of the only programs of its sort in the nation.

Gauging Effectiveness in Educating the Public

There are several strategies the zoo utilizes to gauge their effectiveness in educating the public. Educators are trained to quickly provide a skills assessment in order to learn what individuals know and need to learn, Gates also always requires her staff to understand the latest research on their topic. “If they don’t know the newest research, they could be missing a vital piece to their work.” She does this by providing staff training on specific research and has purchased memberships to several well-known zoo and science education organizations. Gates shared her staff assign a task at the end of a presentation that requires individuals to share their learning using the added information. They also work to create real-life applications throughout their interactions, as she believes that is a straightforward way to make information “stick”.

To effectively communicate science with the public, June believes they need to ask three questions: "Why are we doing this? Who are we talking to? What does that person need to be successful?" She also believes creativity plays a significant role in engaging individuals in science. The zoo educators are always encouraged to look back at the goal and objective. "We have to know where we are trying to end up because it is incredibly easy to veer off the course." June shared the zoo's top line object is to 'nurture critical thinking.' June shared that to communicate science to the public effectively; you must stay true to what you know. "The zoo effectively communicates science by remaining true to what we know and what we care about."

Building Programs and Outreach

The zoo determines programming focus through two methods. The first method is through school districts' requests close to the museum. According to Diane, "because we have such a close partnership with several area schools, we allow their standards and interests to drive the co-development of a large majority of our programmatic offerings. If they come to the program, we are more likely to offer it." The other determining factor for zoo program development is that the programming and exhibits must focus on living things. The educators allow current events, such as global warming, on specific ecosystems to drive programming. June mentioned the less desirable but just as influential a method to get new programming or exhibits at the zoo: pressure from donors or board members.

> A few years ago, we had a board member who was incredibly fascinated with Panamanian frogs. The frog exhibit didn't support anything we were doing as an institution, but because of their interest, we worked to create an entire exhibit on the species. The donor donated all the funds required to create a new exhibit. Due to their extreme interest in the species, they marched any friend they could find through the exhibit which did increase our attendees. We worked to find ways to tie the new exhibit into our school and family programs to ensure the space was utilized to its fullest.

Case 4: Dallas Zoo

Morgan McDaniel Background and Experiences

Morgan McDaniel is currently employed at the Dallas Zoo as an Education Supervisor. Morgan started in the public sector, working as an environmental scientist. She eventually realized she wanted a bit more human interaction, so she moved to work as a K-12 educator at a small science museum near her house. During that time, she began working on a degree in free-choice learning at Oregon State University. Once she graduated, Morgan started working as a high school environmental science teacher. Through that employment, she got an opportunity to begin working at the Dallas Zoo as an education supervisor in 2013. Over the last eight years, Morgan has moved from being an entry-level educator to becoming the program coordinator for Youth and Intergenerational Programs.

Morgan shared, according to work done by Falk and Dierking, “only 5% of a person's life is spent in a classroom. 95% of your life is spent learning informally.” While informal science centers are afforded the chance to utilize engaging techniques schools don’t have access to, they must partner with formal education to support learning done in the classroom. Another role informal science venues play in society is the ability to model how to find valid and accurate information. With the war on science louder now than ever, Morgan opines, individuals with skills in science and science education have a responsibility to model how to accurately track down information and apply it to their previous understandings. Another role informal science plays today is the access they provide underserved individuals. “While people may not feel comfortable walking into an art museum, there’s something about a hands-on science experience that levels the playing field,” Morgan states.

Dallas Zoo History and Overview

The Dallas Zoo was established in 1888 and is the oldest and largest zoological park in Texas. The zoo is home to over 2,000 animals and 406 species. The zoo's first purchase was two deer and two mountain lions for $60. In the early 1890s, the Dallas City Council approved funding the zoo, allowing more animals to be purchased. In its original location until 1910, the zoo was temporarily relocated to Fair Park. In 1912, the zoo moved again to a larger plot of 36 acres in Marsalis Park, located to this day. In the 1920s, the city of Dallas created a special commission that further developed the collection. During the Great Depression, the zoo underwent significant renovations that the Works Progress Administration funded.

In 1955, the Dallas Zoological Society was established to provide a support structure for the institution. In 1966, the zoo housed over five hundred species of animals, but in the 1980s, there was a large movement to look at how science treated and supported captured animals. The zoo switched its emphasis from species' quantity to preserving endangered species. In 1985, the Dallas Zoo was accredited. Over the last forty years, the zoo has continued to undergo extensive renovations and expansions.

Today, the zoo is divided into two main sections: ZooNorth and the Wilds of Africa. ZooNorth contains the original elements of the zoo and is the oldest section. Found within this section is the endangered tiger habitat, the children’s zoo, which includes a petting zoo, pony rides, other interactive displays, and Bug U!, an exhibit that teaches visitors about the zoo's invertebrate collection. Within the *Wilds of Africa* section, visitors will find the *Penguin Cove*, Chimpanzee forest, the Gorilla Research Center, Crocodile Isle, Forest Aviary, and the Adventure Safari. The Safari is a 20-minute, one-mile, narrated monorail ride that brings visitors around the zoo. In 2010, the Giants of savanna extension was opened, which added 11-acres of expansion and provided a new home for various animals, including elephants, giraffes, zebras, and wild dogs. In 2011, the zoo received recognition from the Association of Zoos and Aquariums for the new exhibit area. The newly created habitat was the first in the world to combine the variety of large animals in one exhibit to re-create better what one might see in the African savanna.

Today, the zoo has over 350 employees and 750 volunteers. The zoo's board has 53 active members. The Dallas Zoo website did not provide information about leadership or specific titles, but I could find that information on a third-party website. I could not find any particular mentions of educators or education leadership.

Institutional Organization

At the Dallas Zoo, the Director of Education reports to the Vice President of Conservation and Mission. The education department is organized into formal and informal education units. Within the informal education department, there were conservation and engagement educators. Under that category were housed the interpreters and adult volunteers and twelve part-time volunteers. The formal education department had a deeper hierarchy, starting at the top with an education director. Under the education director, the Operations manager oversaw reservations and ticketing/rosters, a Preschool Manager, who led two licensed preschool teachers who conducted early childhood programming, and the Education Manager. The educational resources manager was under the education manager and oversaw three specific programs: youth programs, school programs, and family/intergenerational programs. The zoo had a docent program until the end of 2019 when they decided to move away from that structure. The zoo felt the effort to organize and maintain the volunteer base necessary for a quality docent program was not worth the resources required.

Programmatic and Educational Offerings

The Dallas Zoo offers a wide variety of event options that utilize both the institution's space and resources. Some of them are found below.

The *Animal Adventures Outreach* allows people to rent animals and their keepers for presentations. They will travel to your location and provide in-depth demonstrations about the animal selected. Due to COVID, the zoo has made this offering virtual with the zoom platform.

The *Wild Adventures Camp* is for students in Kindergarten through fifth grade. These camps range from one day to one week and allow children to go behind the zoo scenes and learn about a variety of conservation topics and animal information.

In the *Backstage Safari* program, visitors experience the zoo from behind the scenes by taking a 90-minute guided tour and learning how individual animals are cared for daily.

Wild Earth Preschool is a nature-based preschool located in the zoo. This preschool provides childcare for children ages 3-5 and includes daily visits to the zoo and a nature-based sensory educational experience.

The Dallas Zoo website does not provide extensive information on a field trip or school-based opportunities. They have one page of information that includes admission costs, parking information, maps, and frequently asked questions.

Tasks, Roles, and Responsibilities of Educators

The youth programs volunteer coordinator supervised all out-of-school programming for students fourth through twelfth grade, including summer camps and after-school experiences. The school programs manager oversaw all field trips and school outreach. The zoo provides opportunities for students to visit and participate in programs, but they also travel to destinations outside of the zoo with animals. Another educator is responsible for teacher professional development opportunities. These workshops cover various topics, from science-specific content to learning how to incorporate art in the sciences. The Dallas Zoo also offers *Project Learning Tree* (PLT) and Project Wet/Wild certifications. These trainings are offered for teachers and other informal science educators and provide a database of lesson plans on topics surrounding a variety of life science topics. During the summer, the zoo provides two different week-long summer institutes where teachers learn how to incorporate hands-on science learning in their science classrooms. Another individual was responsible for writing all curriculum used by camps, programs, and school programs. This person was a previous teacher, so she had an extensive understanding of the standards.

Morgan, the family, and intergenerational program manager was responsible for everything "K though grey." She oversees thirteen programs while in that program. The zoo worked hard to provide experiences that families could do together. The zoo offered monthly family nights, where activity stations and scavenger hunts would be set up around the park. "We wanted to ensure that every person who came to the zoo left feeling like it was worth their time." They employed three full-time educators who vacillated between the three departments. During the summer, the zoo typically increased the number of educators they had on staff to meet the increased demands. These educators were often employed in local school systems and participated because they had summers off.

The zoo had a large amount of overhead required to operate, so educators spent a large amount of time proposing money-generating activities. The zoo, according to Morgan, had a reputation for putting together beautiful programs. They offered special night events around holidays, such as Halloween. They also provided camps, night hikes, and sensory-friendly family nights. Educators were responsible for all logistics surrounding those events, from ordering supplies to facilitating experiences. The zoo also created and offered a large variety of school programs to educate students and "interest them enough to bring their families back for a second visit." These larger events were assisted by the volunteer staff, many of whom were retired individuals.

When COVID 19 closed the Dallas metroplex, the zoo had to make some challenging calls to save money. The only educator the zoo retained was the Director of Education. All education instructors were re-assigned as zookeepers. Educators within the zoo were furloughed in August 2020.

Perspectives of Commonalities between Educators at the Zoo

While there are plenty of shared characteristics Morgan feels would make a good science educator, flexibility is the first skill they look for. "Things never go as planned, so we need to know the people we hired have to adjust to the change and continue moving forward." After flexibility, the zoo wants people to appreciate and be passionate about science. In prompting, I asked if they required their staff to have a deep understanding of science content, and before I could even finish the question, Morgan shouted "No!". "We want them to have basic elements of scientific processing (the ability to think scientifically, but we are willing to train for a deeper science content knowledge." Morgan found in her experience that individuals can always be taught content, but they can rarely be taught people skills and enthusiasm. Once hired, the zoo completes intensive training and job-specific development.

Gauging Effectiveness in Educating the Public

According to Morgan, while the Zoo does not have formal observation programs, it works to track experiences through post-experience evaluations. These post-evaluations were presented by creating logic models that were formed for each formal program provided. Due to the zoo's focus on conservation education, most of the conservation mission evaluation. “The big measurement for us as if they understood about a conservation action they could take when they left a program.” The zoo also tracked program participation to investigate interactions over time. “We would follow students who signed up as girl scouts and then transitioned into the youth programs...or maybe a toddler began in the stroller buddies' program and then moved into an early childhood program. We wanted to know if people were returning.” Morgan did share that majority of assessments were provided with pen and paper. “I believe I was the only program director utilizing online resources, such as Google Drive, to provide assessments and track data. There are a lot of people who just do not understand the need or importance for assessment.”

The Zoo’s main goal was educating a future society on the importance of conservation and current scientific understanding. “If people left with an action step on something they could change or continue in their lives that was making a difference in the generation of global warming and ecosystem destruction, we considered our efforts a success.” Morgan shared they did not only want people to leave with new content area understandings but also the responsibility of a call-to-action. “The ultimate measure of understanding is when an individual can take what they have learned and apply it to their life outside of our institution.”

Effectively Communicating Science to the Public. Rye stated, “the most important method you must use to communicate science is meeting someone on their level.” She discussed how individuals aren’t likely to return to a place if they leave feeling stupid or inadequate. Once you have found the level of background information and understanding a person brings to the table, “we begin by looking for interests. If we can make something relatable, it's automatically more enjoyable.” The zoo made every effort to avoid scientific vocabulary or colloquialisms, as individuals would shut down if they felt something did notmake sense.

Another vital piece of information necessary for educators is any misconceptions visitors may have. “If we don’t know misconceptions, we aren’t sure where to start or what information we need to include.” Museum educators were trained to ask guiding questions and listen closely to guests' responses. Those responses explained two things: “what people know and what they want to know,” according to Rye. “We can find out quickly if a person just wants some basic background information or if they are coming to us with a background in ecology and ready to learn more. Those quick checks help us determine what to share and even what language to use.”

Building Programming and Outreach

There are several methods the zoo utilizes to design programs and outreach. When creating plans for schools, the zoo provides a questionnaire to schools to determine gaps and holes that may need to be addressed and any information that may help the museum educator provide the programming.

> While our programs are predetermined and teachers pick from a menu, we do want to make it worth their time. Ensuring we use the same vocabulary and language a classroom teacher has is incredibly helpful. If students are coming in to do a lesson on ecosystems, but don’t know the word biome, we need to know to find a way to introduce the language. These surveys are vital to what we do.

Those school partnerships are significant in determining future programming. “If a school we have a previous partnership with is working on something with, let’s say, penguins, we are much more likely to create a program or experience on penguins.” Because Morgan was a formal teacher before moving to the zoo, she understands the importance of standards and tying experiences to the standards to allow educators to justify the expense and time spent outside the classroom. Educators in all departments work to ensure programming is specific and goal-oriented, both to the zoo's needs and the schools.

Another practice that educators at the zoo employ is asking individuals what they are looking for in an educational experience. When they offer night programs to adults, the zoo always asks them what they are looking to get out of the event. That short answer helps guide the experience and approach they take. Their responses also help the zoo make changes to previously existing programs, as they are sometimes the only evaluative point offered. When events are popular, it helps the zoo determine the direction to take future occurrences of that type.

Finally, pre-existing partnerships with organizations in the area can dictate programmatic and outreach focus. Morgan shared an example with the Alzheimer's Association.

> The Alzheimer’s Association reached out to us about needing to fill a gap for their elderly audience. We realized we could help, so we formed a partnership with them and began creating programs that could be great in helping that specific population. They aren’t the only organization we have done that with. The autism support network reached out and asked about sensory options for families with children who have sensory issues. We were able to create several sensory nights that have not only become very popular, but also created a culture of zoo visitors who return over and over.

Role of Informal Science Facilities

Morgan shared a study they found important where most people only spent 5% of their lives in a classroom and 95% of your life learning informally. Museums, zoos and centers, she shared, can provide people with access to current information or experiences in a non-threatening environment. Additionally, the zoo knows it is important to teach people how to find valid and accurate information. She shared about their current experience with individuals and COVID and the importance of having current information.

Case 5: Michigan Science Center

Esther Park Background and Experiences

Esther Park started as a student at Wayne State University. While a sophomore at the school, she began interning at the Michigan Science Center, located across the street from the college. After graduating, she realized she enjoyed her time at the museum and accepted a position as the outreach coordinator, which supervised in-person and distance learning. After a few years, she was promoted to the Outreach Program Manager.

According to Esther, science museums, centers, and zoos play a variety of roles in a person's life. “The most important thing these places provide is an informal experience. Schools are bound to standards, which don’t allow for much flexibility. Science centers can bring science to life and cater to interest much easier than a traditional classroom environment.” Esther also believes informal science centers can make science inspirational and develop lifelong interests and passions in the next generation. Finally, science centers, according to Park, “can individualize everything and create an experience unique to the visitor.” Learning in a science center removes the pressure of being required to retain every piece of information and allows visitors to interact with information in a pressure-free space.

Michigan Science Center History and Overview

In 1970, a storefront was leased and used to start a new science museum. For the eight years that followed, the museum offered opportunities for the inner-city youth of Detroit and others to engage in the science museum. As the museum's popularity grew, it afforded them a chance to bring on full-time staff who could better run the operation. On January 23, 1976, they began construction on a new, 45,000 square foot building. The new facility consisted of three levels and a newly created IMAX theater. Twenty-three years later, in 1999, the center began a

$30 million expansion and renovation project that would completely overhaul the original building. The project would be completed in July of 2001 and provided a facility with more than 110,000 square feet. In the fall of 2009, the Thompson Foundation funded a four-story building with 80,000 square feet attached to the center. This building provided space for a new entrance, store, group meeting space, and a science and math charter school.

In September 2011, a financial crisis forced the Detroit Science Center to close its doors. Several months later, several philanthropic community members created a new nonprofit organization called the Michigan Science Center, or MiSci. The organization purchased the former Detroit Science Center building and reopened its doors. Today, MiSci houses live show stages, an IMAX dome, a 4D theater, a Planetarium, 8,700 square foot special exhibit hall, and over 200 hands-on exhibits.

Institutional Organization of the Science Center

Under the CEO of the Michigan Science Center, there is a Chief of Education. After the Chief of Education is the following Education Managers: Extended Learning (scouts, homeschool programs, early childhood), Outreach Programs (off-site and online), and Floor Coordinator. The educators employed by the museum, both full and part-time, are shared among all departments, so they have a deep understanding of the museum's inner workings. Volunteers for the Michigan Science Center do not report to the education department but rather the marketing director.

Organizational Structures Impact. According to Parks, all departments support education. “They don’t come to see how clean the bathroom is, but we want them to leave thinking the bathroom was clean.” This partnership between departments is what makes the museum successful. “At the end of the day, everything we do should support the mission of the center. That helps avoid conflicts and ego because we all want the same thing.”

Programmatic and Educational Offerings

There are several programs offered on-sight and virtually through the Michigan Science Center. All programs are created and run by the educators on staff.

ECHO is a program provides weekly free virtual science demonstrations on various topics. Students can submit questions to museum educators and interact with staff.

Virtual field trips afford schools who cannot take a bus to the center a chance to still participate in programs and self-paced lessons on a variety of STEM topics. They also provide a list of further investigations and topic extensions that can be done in the classroom or at home.

Traveling Science brings science center educators to your location, where they provide a variety of interactive workshops and demonstrations.

STEMinista is a program, targeted at girls, provides education and experiences in various STEM fields to increase the number of females in the sciences. Through these hands-on activities, the center works to interest girls in pursuing science classes and eventually careers by providing exposure to a variety of fields.

The museum's additional events include special overnight events, day camps, and summer camps for children 3^{rd} through 8^{th} grade.

Tasks, Roles, and Responsibilities of Educators

Educators within the Michigan Science Center (MiSci) are responsible for three main areas: facilitation of programs, development of programs, and live theater and stage experiences. Educators are responsible for on and off-site program implementation. MiSci can be scheduled to host programs throughout the community and work hard to provide scholarships for communities that cannot afford a center visit's full-price tuition. These off-site visits include programs, demonstrations, and hands-on opportunities. This program is called Traveling Science and is hosted and run by distance learning educators. Individuals requesting programs can provide topics they are most interested in learning about, and educators at MiSci create programs to support the request.

The education department is responsible for designing all programs, including shows, presentations, and field trips. The center's culture allows educators to utilize a variety of resources and request help from other departments on site. Facilitation of programs includes programs for regular visitors and special guests. Programs include demonstrations and shows offered throughout the center. Examples of the programs offered include chemical reactions, kitchen chemistry, and light.

Educators who run the live theater and stage experiences implement the program. One interesting fact about the Michigan Science Center is that over 50% of their educators have backgrounds in stage production or theater. Esther shared they appreciated the experience in stage and theater "You can teach the science content you need them to share, but you cannot teach the skill set that includes the confidence to get on a stage and sell it." The center has six different galleries throughout the facility that provide a stage and seating for viewers. The theaters that provide movies or shows are an IMAX Dome gallery that shows videos, the Planetarium, which provides a tour through the galaxy with the help of an educator narrating, the 4D Engineering theater state of the art projection systems to show 3D videos. The educator-led galleries include the science stage that houses live programs and demonstrations throughout the day. The Energy Sparks Theater shows how electricity affects all facets of life and the kid's town theater, which provides programming for pre-elementary children.

The educators also create a free lab resource database for families and teachers. The digital resource includes an activity overview, materials list, and directions. At the end of the resource, educators provide a short explanation of the scientific principle used in the lab. Bacteria growth plates, crystal paintings, and pocket solar systems are just a few examples of free digital labs located on their websites. Other jobs include ordering supplies, meeting with other departments about upcoming needs, and analyzing feedback for possible growth opportunities.

Educators' view on their roles. Educators know the work they are doing, shared Parks. “Education is why museums exist.” Educators know informal education provides a very different experience so their impact can be far reaching. Parks feels educators are the bridge between formal and informal education. “We provide structure for visitors while still affording them flexibility.” She said “our job is to inspire a lifelong relationship with learning. If we do that, we’ve done our job.”

Perspectives of Commonalities between Educators

When hiring staff, MiSci doesn’t look for individuals who have deep scientific content understanding, but rather individuals who are “confident in public speaking and understand the people-centered approach to explaining science we are taking.” If an individual has K-12 experience as a student, Parks believes, “we can teach them everything they need to know.” One thing that makes the MiSci center unique is the variety of experiences their education department brings. According to Esther, over 50% of their educators have backgrounds in theater, which “makes them great with kids, engaging, and able to pull from a large amount of people skills.” Included on the list of people skills, Parks listed skills such as flexibility, good-natured, jovialness, and willingness to work on a team. Due to the diversity of their educators' backgrounds, the center provides training and development continually and shadowing opportunities.

Gauging Effectiveness in Educating the Public

The Chief Learning Officer and Program manager are certified in the PEAR assessment. That assessment tool is specifically designed to evaluate informal learning experiences. PEAR stood for Partnerships in Education and Resilience and was created in 1999 by Dr. Gil Noam, a Harvard Graduate School of Education professor. This tool offers two different assessments, the Common Instrument Suite (CIS) and the Dimensions of Success (DoS) assessments. In the CIS, individuals self-report attitudes about STEM, including interest and engagement. The purpose of this tool is to “better understand how informal STEM programming impacts students’ perceptions/attitudes towards STEM (Assessment Tools).” The DoS tool is formatted towards informal learning experiences and provides recommendations on how programs can give the STEM programming quality. The DoS “allows researchers, practitioners, funders, and other stakeholders to track the quality of STEM learning opportunities and to pinpoint strengths and weaknesses.” MiSci uses both the CIS and DoS assessments, dependent on the information they are trying to gather.

Due to the tool's particular protocols, it cannot be used for everything. In place of the PEAR assessment, the center also uses a tool called “Formstack” that has surveys designed on every program they house. For quick experiences and programs, the survey will ask a question about what the visitor liked most. Education programs get a much more in-depth survey. “Teachers are always willing to complete a more detailed survey on their opinions of whether a program met their curricular needs.” The survey includes questions about pre-and post-visit resources and materials provided. The MiSci Center realized individuals are more likely to respond to a survey if the experience they are evaluating was a paid experience.

Another thing MiSci does that I found interesting is the marketing team compiles quarterly reports on social media reach, google reviews, and Facebook comments. Those comments and thoughts guide future programs and implement changes in current programs. This report is shared with the executive team, which, according to Esther, "created a bit of collaboration when there may typically not be any." Feedback is a necessary assessment tool the center does not take for granted. "We want people to feel like they had fun and learned something. Not only does it make the experience worth their time, but they will tell their friends and return!"

Effectively Communicating Science with the Public.

According to Esther, the science center's first responsibility is to "spark curiosity." "If people aren't interested in what we are showing them, nothing they do on-site matters," Esther states. Another way to effectively communicate science with the public is by relating it to real-life situations.

> You shouldn't teach science just to teach science. You should teach science as a way to think about the world around you. Making things around us that may be abstract more understandable ensures individuals don't feel defeated or unable to relate to the information we provide.

Esther also shared the goal of educators is to "inspire people to go out and find science in the world around them." When they communicate science in a way that is understandable and desirable or curiosity sparking, Esther believes they have done their job.

Building Programming and Outreach

According to Esther, the CEO for MiSci creates a strategic 5-year plan with specific outcomes and objectives. Once he releases the strategy, programs are designed to support the upper administration's goal and vision. “As educators, we want to constantly be ensuring that our programming and experiences we offer supports and aligns to the centers core mission and values. Not only does it ensure we are aligned institutionally, but it helps us when we need to justify financial and programmatic decisions.” The center also works hard to align with upcoming events and national themes. One theme they follow every year is the National Reading Theme. They will create at least one program or exhibit that supports the theme. Other events that may drive exhibit or event creation include anniversaries and STEM events. For example, on the 50th anniversary of the Apollo 11 moon landing, the center made various programs and classes surrounding that event. They also try and educate guests about famous scientists and inventors throughout history. “We use the idea of imagining your own story to get people thinking about scientists in the world around them and not only how they changed life for humanity, but how the visitor can also make an impact.”

Another thing the program attributes to influencing programmatic creation is feedback and requests from local schools and teachers. “We value teacher feedback and utilize that to help determine our next steps. We never want to create a program that wouldn’t be of use to the people who utilize our resources”, Esther stated.

Role of Informal Science Facilities

Museums and science centers provide an informal experience, shared Parks. “We can inspire someone to learn more about something they may not understand. That power is important.” Informal learning centers are also accessible to all people, which is not always common. “We provide individual and unique experiences to every visitor. While they may experience the same exhibit or talk, they still walk away with a completely unique experience. That’s pretty cool!”

Case 6: Perot Museum

Caitlyn Stephens Background and Experiences

Caitlyn Stephens spent 22 years with the Dallas Museum of Natural History. Before her experience there, she received a degree in Anthropology while living in Florida. She knew she wanted to work in a museum, but the small town she lived in a while in Florida was not close to any museums. Her husband was transferred to Dallas for work, and Caitlyn knew that was her moment! She quickly accepted a job with the Dallas Museum of Natural History and knew she found her passion. When the Dallas Museum of Natural History consolidated with the Science Place and the Dallas Children's Museum to create the Perot, Karen was given the role of senior manager of school programs.

Museums play a crucial role in society, according to Caitlyn. "Museums are places that model the importance of lifelong learning. People who come to visit should leave understanding the importance of lifelong learning on their lives." Caitlyn also stated that museums model the real-world application of science, and visitors should be able to identify science and the role it plays in their daily lives. These centers should be inclusive, and every visitor should leave finding something that represented them. "We don't ever want people to come and feel as though there was nothing that could relate to them."

Perot Museum History and Overview

The Perot Museum in Dallas, Texas opened in its current location in 2012 with roots dating back to 1936. In 2006, three previous Dallas institutions, the Dallas Museum of Natural History, established in 1936, The Science Place, established in 1946. The Dallas Children's Museum, established in 1995, merged to create the Perot Museum. This unique combination brought together decades of collections and research and invaluable educational practices that would make a museum capable of entertaining all ages. In May 2008, Ross Perot, the museum's namesake, donated half the $100 million needed to purchase the Victory Park facility, eventually becoming home to the Perot Museum of Nature and Science. The 180,000 square-foot museum stands approximately 170 feet high and houses five levels of exhibits and experiences. The total project cost $185 million. The museum's features include 11 permanent exhibit halls, a traveling exhibition gallery, an education wing with six learning labs, a 297-seat cinema, and a flexible space auditorium.

The Museum is unique because its creation was from the consolidation of three previous institutions. The Dallas metropolitan area has a population of just over seven million people and covers over 9,200 square miles. Within that space are 69 different museums, including art museums, children's museums, historic houses, and other informal learning centers (Museums USA, 2020). Of those 69 institutions, nine of them had some tie to science, with zoos, aquariums, science centers, and museums.

Institutional Organization of the Perot Museum

The Perot Museum is led by Linda Silver, Ed.D, CEO. Under the CEO is two Chief Officers, Chief Operating Officer and Chief Financial Officer. Before COVID, there was also a Chief Assessment and Evaluation Officer. Under the Chief Operating Officer is housed education. Within that department, there are three directors: Community Engagement, Camps, and Education. Under the directors fell the entry-level educators and outreach coordinators. The Perot employed 30 part-time staff and around 20 full-time educators at any time. When asked, Caitlyn shared volunteers fall under a different organizational structure. The board overseeing the Perot Museum currently has 37 members. Also found in the 2019 impact report was this excerpt on education.

> Following an in-depth evaluation and needs assessment of the educator community, we made major changes to our on-site and campus-based education programs. The resulting lineup streamlines Museum resources and better aligns offerings with teacher needs and the new Texas Essential Knowledge and Skills (TEKS) curriculum with programs for students in Physical Science, Life Science, and Earth and Space Science. As a result of the new programs and optimized strategies, school on-site sales trended up for the first time since opening, and outreach program revenue grew 9% over last year. We have continued to invest in the STEM Teacher Institute to equip area educators with relevant knowledge and techniques for the classroom. This year, we developed the skill sets and confidence of 25% more teachers than the previous year. These teachers represent approximately 20,000 students who will ultimately benefit through this important professional development program. With the intense training provided by the institute, we have formed a robust foundation from which to diversify and scale professional learning programs to support teachers and improve student engagement in the formal learning environment (p.10).

Programmatic and Educational Offerings

In addition to the regular outreach the museum provides through visitors and exhibits, the Perot is home to several specialty programs.

Two *TECH* (Tinker, Engineer, Create, and Hack) trucks bring free STEAM programming to the schools in the museum's community, including those who may not be able to visit the museum physically. These trucks house eight hands-on stations that utilize 3D printers, laser cutters, computers, and art supplies. Topics students may learn about while interacting with the truck include robotics, coding, engineering, and art. The trucks are operated by educators who provide programmatic assistance once they have reached the site.

National Geographic Live Series provides lectures by some of National Geographic’s most prominent explorers and covers various informational topics. Due to COVID protocols, the series is currently being offered virtually.

STEM Teacher Institute is a year-long institute provides teachers with workshops and tools to bring STEM to life in their classrooms. Through the course of a 4-day summer workshop series and four seminars throughout the school year, teachers gain a more in-depth content knowledge of what is necessary to facilitate STEM in their classrooms, inquiry-based skills, hands-on experiences, and an opportunity to grow their leadership skills.

Throughout the summer, students from pre-K through sixth grade can learn about various topics from space, animals, dinosaurs, chemistry, engineering, and other issues while enrolled in Discovery Camps.

The Paleo Lab allows visitors to watch the museum's dinosaur research in real-time. From these windows, visitors can watch paleontologists and the preparation process and research fossils found in the field.

Started in 2018, these *Centers of Excellence* highlight specific places within the museum that may highlight additional educational opportunities for the public. There are currently two centers for excellence: the Center for the Exploration of the Human Journey and the Gems and Minerals Center of Excellence. These centers work on gathering and disseminating research that is currently being done in these fields to further the institution's educational initiatives.

Tasks, Roles, and Responsibilities of Educators at the Perot

Educators at the Perot are responsible for a variety of tasks and roles. A critical aspect of work is to develop a curriculum that supplements the museum's work within classrooms. This goal is accomplished through on-site visits by museum educators. These programs cover various topics, including DNA, the cretaceous period, and even dissections. These programs' goal is to highlight work being done by museum scientists and collections displayed so students can make connections if they visit.

They also plan and prepare all programs and shows within the museum. The museum's early childhood program provides age-appropriate lab opportunities for children and their parents to participate. Educators are also responsible for creating and delivering programming for day camps and overnight events. They also generate programming for adult events throughout the space. One unique offering is their "Day in the Life" program, where individuals can spend an entire day with an expert within the museum, participating in various activities and learning what it means to be a scientist in that field.

One unique thing to the Perot was the inclusion of science communicators within specific exhibits. Their goal, as hybrid educators, was to engage visitors, quickly determine their skill and interest level, and then leave them with at least one new fact. Educators also taught classes on the museum floor and in the lab spaces located within the museum. As every museum interviewed shared, one of the most essential things educators do is create opportunities for revenue-generating experiences. Birthday parties, camps, sleepovers, and lab events were just some of the extra-curricular, money-generating events put on by the Perot staff. The Perot Museum has two "tech trucks," that are trucks full of STEM-related activities that can drive to various locations around the Dallas Metroplex and host events. Two full-time educators were assigned to each truck, so their responsibilities look a bit different than the rest of the educator pool.

The twenty to thirty part-time educators helped with on-site teaching, science nights, and other special events. According to Caitlyn, "The holidays are always an easy time to push a special event. We would host sleepovers within the exhibits, and part-time educators would assist in ensuring the event was a success." Purchasing supplies, stocking spaces, and keeping areas ready for the next group also fell under the educator's umbrella. Finally, the education department is also responsible for training all Perot staff. They would hold different trainings around educating the public, science communication, and incorporating inquiry into their presentations. The education department also has a professional development team that works to provide training to local teachers through a variety of hands-on workshops.

Educators View on their Roles. **“**Most people come for an experience tied to education,” shared Stephens, “so our jobs are important!” She also shared educators can have a large impact on guests and their experience and are the key to the museum's entire success. “We are the only people with our hands in every pie. We teach content, build products, provide training to the rest of the staff- we do it all!” Other teams lean on us while performing their jobs. For example, we may help the individuals building the exhibits with the content and information they choose to include.

Perspectives of Commonalities Between Educators

When I asked Caitlyn how they determined how to hire new educators for their team, she said they look at the current team they have in place and try to find people who can strengthen areas where they are weak. If they are struggling with finding individuals who can be great presenters, that is a skill they highlight in the interview process. Because the educators work in collaborative communities, it is crucial to have a well-rounded team to provide support, Stephens shared.

Another characteristic they look for is flexibility. The education team may work with two-year-old and 70-year-old individuals on the same day, so being able to change the way they manage a space and the way they interact with individuals is vital to their success. The Perot does not require a science background, but instead looks for individuals who appear interested and excited about teaching. The museum says they can teach anyone science content, but they cannot teach enthusiasm. Stephens also reported that they look for evidence of lifelong learning and interest to continue learning. “If we are modeling the pursuit of furthering one's understanding of something, we must also be life-long learners ourselves.”

Gauging Effectiveness in Educating the Public

When the Vice President of Evaluation was still employed (pre-COVID), she and her team worked to create a database of evaluations that could be utilized by any program area. They also used individuals to circulate the museum floor with iPads and ask questions about experience, perception, and impact. Aside from the evaluations collected, the museum leadership team closely monitors the programs and events that receive the most bookings. Those numbers help determine future topics and events that the museum will host.

Caitlyn felt their education department closely monitored what was happening within the world of education and responded appropriately,

> We employed a lot of individuals who understood standards, or at least the importance of adhering to them. We would also pay close attention to the Texas Standardized test and try to find activities and experiences that would support it. We knew we needed to give teachers not only a reason to come to the museum, but we wanted them to leave feeling it was worth their time. When teachers participate in a school program, we have extensive surveys we ask them to fill out, and that information helps guide and direct the direction we go in the future.

Effectively Communicating Science with the Public

Caitlyn firmly believes the most important key to effectively educating the public is to make them feel welcomed and excited. “I always tell our educators to work to find something they do know. If they realize they have even a small piece of background information on a topic, it is much easier to get them to jump in.” The museum has also worked hard to be an inclusive place. They recently updated their organization to include a statement about diversity and inclusion (Equity, Diversity, and Inclusion, 2019). “The Perot Museum of Nature and Science strives to exhibit diversity and promote inclusion in all aspects of the organization, including, but not limited to, programming, staff, audience reached, and Board of Directors (p.2).” it reads She also feels museums should engage in a way that feels both inspiring and accessible.

> People should leave our space feeling like they can make just a small change to make the world a better place. We want them to be inspired about not only the world they're living in right now but also the world they will live in in the future. If a visitor comes and is made to feel stupid or inadequate, we don't get that opportunity back. We must make everyone, regardless of background, feel as though they have found a home.

Building Programming and Outreach Focus

The first method the museum uses to determine programming and outreach is to analyze the state department of education's standards and alignment guides. “We have to be able to help people justify why they are visiting our museum.” Every program is TEKS aligned (Texas Standards) to provide teachers information about the covered content. Because the museum is utilized so frequently by local schools and students, they work to ensure their programs support their work.

The museum also utilizes feedback from visitors to create new ideas. “If someone offers a suggestion that we could make work, we always try to honor our guest's requests.” The museum relies heavily on memberships, so giving the visitors, especially members, a voice ensures they feel heard. Board members can offer suggestions, but they do not provide a powerful say in determining focus and direction within the education department. The museum also finds ideas for their exhibits and programs by monitoring current events. They pay close attention to scientific topics currently impacting their geographical region and the world and work to create exhibits that could educate people on those topics. When I asked Caitlyn if they had a lot of pressure from the board to create specific experiences, she replied

> ...honestly, not really! Our development team worked incredibly hard over the last few years to create a barrier between the donors/board and the education staff so they don't feel as though they can request random projects anymore. For a while, we were getting the most random requests that didn't align with our mission or vision, and it's a fine line between saying no and honoring the requests of your board. Development really does an excellent job of flushing out the bad ideas and bringing us only the ideas that may be possible.

Role of Informal Science Facilities

Museums are houses of lifelong learning, according to Stephens. They are a place to interact and learn real world applications. They are also places of inclusivity that provide experiences for all people. Finally, they can highlight the future of science and informal science learning.

Case 6: North Carolina Museum of Life and Science

The North Carolina Museum of Life and Science provided an additional mission statement specifically for their educational program (Educational Mission and Philosophy) critical thinking skills.

> Science is best learned through active practice and engagement with scientific behaviors, including exploration and discovery, gathering and interpreting data, forming inferences, and testing ideas. The Museum provides materials, spaces, and experiences that encourage active investigation, curiosity, and inquiry. We create experiences to promote a sustained, ongoing journey of critical thinking and discovery. We value questions over answers, processes over content, collaboration over competition, and experience over memorization. We encourage questioning, argument, trial and error, imagination, creativity, and open-ended exploration in every facet of what we do. Curiosity, wonder, awe, and inquiry are at the heart of what we do. The best way to learn information and facts about science and what it means to all of us is through self-directed inquiry. To do this, we aim to create learning environments, spaces, and programs that foster and support individual learners' journeys. We believe in providing everyone with an ideal climate and setting to learn science. Learners should feel safe, comfortable, and empowered. We believe scientific literacy and critical thinking are central to maintaining a healthy democratic society. Science is both a community and a tool. When you understand how to use it, it is empowering on its own and has the potential to enrich your life (pp.2).

Raymond Claire Background and Experiences

Raymond Claire had a unique journey before landing in museum leadership. Raymond earned an MPA in innovation and entrepreneurship from Harvard Kennedy School, an MsC in Technology and Human Affairs from Washington University, and a BS In Computer Science from the College of William and Mary. He began in the private sector, doing policy innovation work for the government. His background and expertise are in innovation and innovation management, and he still acts as a consultant in that field to this day. Raymond came to a crossroads in his journey and realized he wanted to do something different. Through connections, he found an open position at the North Carolina Museum of Life and Science and became the Vice President of Innovation, Learning, and Engagement. Raymond also is a Fellow of the Royal Society for the Advancement of Arts, Manufactures, and Commerce (RSA).

Raymond felt informal science education played various roles in the museum environment. On museums specifically, Claire said, "museums enable society to reflect on its past, present, and future- both real and imagined." Informal science education also aids in the evolution of society. "For so many people, their interactions with science are tied to a formal classroom. We have the unique ability to show individuals that science is all around them. Scientific thinking can be applied to so many problems in life."

North Carolina Museum of Life and Science History and Overview

The Museum of Life and Science was started in 1946 as a small trail-side nature center called The Children's Museum. The museum hosted story hour, nature study, clubs for kids and adults, and a preschool. In the years following its start, the museum began to gather minerals and fossils and other natural and preserved specimens, including some live animals.

In the 1960s, the museum secured a long-term lease from the City of Durham for 11.7 acres of land. Construction began on their newest campus and eventually housed the museum's prehistory trail, reptile house, farmyard, aerospace center, geology and education buildings, and many vehicle displays (Museum History). The museum's prehistory trail, which opened in 1967, made history as it was one of the first outdoor dinosaur exhibits in the southeast, featuring 11 life-sized animal models. As discoveries continued in paleontology, the original displays became scientifically inaccurate. Even though that information became well-known, the museum displayed the dinosaurs to draw visitors. In the 1970s, the museum changed its name to the North Carolina Museum of Life and Science. The museum leased a 50-acre piece of land during this time that would become the museum's new home. In 1996, Hurricane Fran left most of the trail impassible, but the museum's brontosaurus can be visited even today.

In the 1980s, the museum entered another phase of expansion and growth, focusing on education. They partnered with Durham Public Schools and added summer camps. They also continued to expand the facilities to make spaces for new exhibits and an auditorium. This expansion was completed by 1993. After the main building renovations were completed, the museum shifted its focus to the outdoors, creating hands-on experiences for their outdoor spaces. This space became known as "Bioquest" and was the recipient of a $2 million National Science Foundation grant, $800 in private support, and $11 million in bond funding from Durham's residents. Today, the museum is 84-acres of "open-ended science and nature experiences designed to spark imagination, creativity, and new ways of thinking about our world (Home, 2021). Guests can interact with 24 different exhibits. One thing that makes the Life and Science center unique from other facilities is the emphasis on using the natural world as a teacher, so many of their exhibits are outdoors.

According to Raymond Claire, Vice President of Innovation, Learning, and Engagement, the Museum of Life and Science is positioned in a unique region. The area has many technology and innovation industries headquartered there, so those companies are willing to donate to organizations that support their cause. The Museum of Life and Science is a part of the "Triangle," an area of museums geographically close: Nasher Museum of Art, Museum of Life and Science, Duke Homestead, Museum of Photography, the Museum of Durham History, NC

Central University Art Museum, and West Point Mill. North Carolina is home to 15 science museums and centers.

Institutional Organization of NCMLS

The museum has a leadership structure with five positions: Chief Financial Officer, Vice President for Exhibits and Planning, Vice President for Advancement, Vice President for Innovation and Engagement, and Vice President for Guest Experiences. The Board of directors has 22 active members.

When Raymond arrived at the North Carolina Museum of Life and Science, he reported that many of his staff are exhausted by the "day-to-day" responsibilities, and due to that, they had little to no room for innovation. Innovation was essential to Raymond because of his innovation development experience during his time with the government. One of the first things Raymond began to reorganize was to add more program managers. Those program managers were "conductors of the orchestra," and their job was to ensure the individuals under them knew the role they were to play. His belief was that if he could remove day-to-day logistical issues from some of his people's responsibilities, he would create a natural space to think "outside of the box."

The four program coordinators are separated into the following categories: school programs, on-campus experiences, camp programs, and community engagement/collaboration. The school programs coordinator works to ensure field trips are organized and students can experience the variety of "opportunity spaces" (exhibits) located throughout the museum. These 24-spaces, located both inside and out, provide opportunities for individuals to participate in science actively. Educators work to ensure the spaces are prepared with materials and information, and at some rooms, even facilitate an experience. Another position that was new to the institution after the restructuring was Catalysts. Claire described these individuals as "quasi-docents" who facilitated scientific discussion on the floor. In addition to those positions, Claire modeled a new program called the "Innovation and Learning Fellows" after the Exploratorium's program. The Exploratorium is a museum of science and technology located in San Francisco, California well known for their creative approach to informal science education. These individuals provide structured professional development support to children and adults.

The on-campus coordinator oversees facilitated experiences and integrated STEM experiences throughout. This includes experiences such as the museum schoolhouse and classes on-site. The camp programs coordinator oversees all camps put on by the museum, including the museum clubhouse. They also help manage the collaborative and grant efforts of the museum. "These people are always focused on revenue generation, but they know that anything we do always has to tie back to the mission of the museum." Finally, the community engagement coordinator oversees the partnerships the museum has throughout the community with various organizations. The museum works hard to maintain a collaborative relationship with Durham Public Schools students and teachers.

The goal of providing more oversight was to ensure times for collaboration and space for brainstorming and creative planning. Under the program managers and educators are the volunteers and junior educators. Claire described the junior educators as "catalysts," which have a very similar role to a traditional docent. Another position added under Raymond's tenure was the "Innovation and Learning Fellows," which are positions styled very similar to those you would find at the Exploratorium. They receive structured professional development support, and in exchange, they act as the delivery agent to children and adult visitors. The diversity of individuals was very strategic to ensure collaboration and creativity. The Innovation and

Learning team had an entire page dedicated to the program's staff under the learning tab. The titles of leadership at the museum are found in the following table 3.

Table 3
Life and Science Museum Educator Titles

Life and Science Museum Educator Titles and Roles	
Job Title	Job Role
Director of National STEM Networks	Lead museums professional learning team that creates and delivers professional learning workshops around the country
Director of STEM Learning	Leads STEM team of educators
Associate Program Manager: TinkerLab	Develops tinkering and technology-based programs and curriculum
Program Manager for Camp Experiences	Designs programming and oversees museums camp offerings
Associate Program Manager: Studio Earth	Creates curriculum and programs for the outdoor nature component of the museum
Program Manager for Public Engagement with Science	Works to build public understanding, engagement and empowerment by creating opportunities for the museum to educate on socioscientific issues
Associate Program Managers	These managers oversee a variety of programs, including Group Experiences, Member Experiences, and The Lab.
Vice President of Innovation, Learning, and Engagement	This individual oversees the education team

Programmatic and Educational Offerings

The Life and Science Museum had one of the most extensive and precise websites I found during my research. There was a tab at the top of the website labeled “learn” and had all the necessary details. The center offers various programs for a family in person, online, and educators. At the center, families can engage in camps, clubhouses, and schoolhouses.

Camps are offered throughout the year and provide students and a chance to explore the exhibit and complete experiments with on-staff educators.

Museum Schoolhouse is a weekly class for families with school-aged children. These classes are inquiry-based and led by museum educators.

Targeted at virtual learners, the *Museum Clubhouse* provides in-person support with schoolwork and offers additional grade-appropriate science activities.

The museum's weekly *Lab at Home* offerings allow students to complete an experiment at home with a museum facilitator's help via Livestream.

The museum offers field trips for any group and provides opportunities to interact with exhibits and learn information supporting the school curriculum.

Tasks, Roles, and Responsibilities of Educators

According to Claire, the role of an educator should have multiple facets. One of the most important tasks an educator can do, according to Claire, is the ability to nurture critical thinking. “Educators should not only be modeling critical thinking for visitors to our museum, but they should also be nurturing critical thinking for the staff that we employ.” Educators are also responsible for assessment and evaluation within all spaces and experiences. Claire wants educators to continually be asking the question, “are we reaching the goal we had when we created this experience/space?” Claire says he asks educators to always reflect on embracing science as a way of knowing, not just a static experience. For example, he shared, “I want people to think less about biochemistry and more about the scientific thinking required to do biochemistry.”

They are also responsible for program and experience design, creation, and implementation. “Educators who create the experience better understand how to deliver it,” Claire believes. The museum is working continuously to make each exhibit as interactive and accurate as it can be. Community collaboration is an integral part of the museum's mission, so Claire wants educators to always be nurturing community partnerships with schools and other nonprofits in the area. They do this by creating partnerships and programs to support the local schools and nonprofits better. Finally, the education department oversees the museum staff training's management and delivery. This occurs through workshops around science communication and innovation, and design. They also created a hybrid fellows program where individuals can enroll as early as high school. This two-year program trains people on providing programs and content to the public. Claire shared a Fellow does a large majority of their programs.

Educators Personal View on their Roles. Educators view themselves as the museum's face and responsible for guests' experiences, according to Claire. “Our educators know they are the individuals within our institution who best understand how to share information and make guests comfortable. While they may not directly interact with a guest on a regular visit if they don’t visit a program, educators play an important role in exhibits and information shared.” Educators also feel they are audience advocates, which Raymond is not the only person to mention this role. Their staff feels they are the person at the table who reminds the other departments how to remain audience focused continuously. Claire explained, “For so many institutions, educators are seen as the ‘gravy on the top, ’ . . . really interesting and nice to have. We are working to make sure individuals in the museum and outside of the space see us as essential to the success of the institution.” When COVID caused places to close, Claire said, “our positions shifted drastically, as we became the department that was ‘keeping the lights on.’” He went on to say their response shaped the way the board viewed them as they suddenly realized how flexible and adaptive they were.

Perspectives of Commonalities Between Educators

When Raymond is hiring educators, one of the most important characteristics he wants is to naturally demonstrate a framework of knowledge around science education. He wants the person to be comfortable using the appropriate terminology. The entire education team at the North Carolina Museum of Life and Science has either a science or education background. Claire shared, “We can be very selective in our hiring process because we don’t just hire to fill a gap. We work to hire when someone can add something to the space.”

Additionally, they ask for experience in either program development or program delivery. When interviewing new educators, one practice they have when interviewing new educators, from entry level to director level, requires them to complete a 30-minute shift on the exhibits floor and observe them. They look for skills such as the ability to answer and ask questions. Claire said, “we look to ensure people ask questions and not just give answers.” They also want to ensure people don’t rush to solve problems or quench curiosity too quickly. Raymond shared, “my favorite characteristics to find in an educator are a love of inquiry- questions are always sexier than answers, curiosity, and the ability to inspire curiosity in others.”

Gauging Effectiveness in Educating the Public

The most important thing the North Carolina Museum of Life and Science does to gauge effectiveness is to look back on the experience's goal and objective.

> Our top-line objective is to nurture critical thinking. When we begin planning a New exhibit or organization, we frame it all through the critical thinking Framework. What do we want people to learn? What do we want them to know? What do we want them to understand? If we ensure that we are connecting our new learning or creations to this framework, we know we will effectively educate the public.

Educators identify a skill or habit of mind for every program. They also identify the desired behavior people learning this would model. “When we know what we are looking for, we know when we have arrived there.” Additionally, the museum always looks back at the goal and objective to ensure they are staying true to the heart of the institution. “When we know our output aligns with the goal and objective, we can better ensure we aren’t putting together something random that doesn’t make any sense.”

Effectively Communicating Science with the Public. Claire believes if you do not appropriately hook a visitor during their first experience with the museum, you may never hook them. “When we are good at storytelling, we can draw almost anyone in,” states Claire. Inquiry can also be the most significant catalyst to learning something new. The museum educators work to provide experiences for people to ask questions because “questions are sexier than answers” as they learn new information. “People don’t want to come into a space and listen to someone ramble on about something. They want to come in and allowed to have a dialogue with someone who may or may not know a bit more about what they are learning.” The museum also works tirelessly to ensure they are meeting the specific needs of underserved and underrepresented audiences. Claire states “we never want someone to walk through the door and feel uncomfortable because of who they are as a person. It is our responsibility to remove the roadblocks that may make them feel inadequate or unprepared.” Raymond goes on to say that “creativity is an innate characteristic in all people that we must work to unlock. We have to go beyond the basics and ask questions to learn what people really know and want to know.”

Building Programming and Outreach

The North Carolina Museum of Life and Science is nature-based, so many of their experiences are located outdoors. That drives the focus of most of their programs and experiences because they want to highlight the spaces they have. After focusing on what spaces they already have, Claire, says they ask themselves two questions: 1) what is the team interested in 2) what is the community interested in? The team of educators constantly interact with new science, so Claire relies on them to bring new and engaging, real-time science problems to the table to create fascinating exhibits and programs. They also take feedback from community members who may have shown interest in a specific topic. Finally, Claire says, they are in the Raleigh/Durham area, which has a large life science presence within the industries located there. The museum works to create exhibits that support the lives of the individuals who visit.

Case 7: The Smithsonian Air and Space Museum

Neil Johnson Background and Experiences

Neil Johnson began working as a museum educator in the late 1990s. He has both a general sciences and math degree. He started as a zoo educator before moving to the Orlando Science Center, where he eventually became the Director of Education. In the early 2000s, he and his wife relocated to the Washington DC area, and he began working as an educator at the Smithsonian National Natural History Museum as the hands-on science center manager. In 2008, he moved to the National Air and Space Museum. His current title is on-sight learning manager, and he oversees educators and their programmatic offerings and some of the exhibit creation.

Science plays many roles in society, according to Johnson. "I believe informal science education is not a necessity, but it is an additive. It improves the school experience of visitors. It also allows them to build on any previous ideas or experiences they may have had." Johnson also thinks informal science can help people interpret ideas or challenges they face in their own lives. "We can teach people how to approach a challenge utilizing a scientific way of thinking. They can hypothesize what they think might happen, learn to ask questions, think critically, gather evidence and data, and arrive at a conclusion. All of that can be modeled and taught using informal science education.

Smithsonian Air and Space Museum History an Overview

The Smithsonian's Air and Space Museum open on the National Mall in Washington, DC, in 1976. The museum's collection began 100 years earlier as they acquired 20 kites from the Chinese Imperial Commission. The early collections were housed in the Arts and Industries Building and eventually moved behind the Smithsonian Castle to a new building that opened in 1920 and remained in use until 1975.

President Harry Truman signed a bill establishing the museum in 1946 to commemorate aviation. The bill did not provide funding for a new building, though, so they would soon outgrow their current space. In 1951, due to a storage shortage from the Korean War, the museum had to move out of the building. The museum's leader at the time, Paul Garber, would move the facility to a site with a variety of prefabricated buildings which would become its new home.

In 1966, President Johnson signed a law changing the name from the National Air Museum to the National Air and Space Museum to commemorate spaceflight efforts. Funding for a new facility was approved in 1971; the facility was opened on July 1, 1976.

At the end of 2018, the Air and Space Museum began a total remodel of all galleries and public spaces that will take seven years. During that time, the facilities will be moved around to allow for closed phases during work. This is the most extensive overhaul of the museum since its opening and has been unique in its approach. The museum has involved current employees from all departments, including education, to dream up the renovations' design and creation. The museum has a secondary location, the Steven F. Udvar-Hazy Center, at the Dulles Airport in Virginia. This smaller location houses a variety of artifacts, including a restoration and preservation center. They also provide science demonstrations and simulations.

Institutional Organization

The Smithsonian Air and Space Museum is organized similarly to the National Natural History Museum. Under the museum, president is the Director, Deputy Director, and Associate Directors. Michael’s role reports directly to the Associate Director of Education. Individuals reporting to Neil include Museum Specialists, Education Specialists, Specialty Educators, Coordinators, and Volunteers. Because the National Air and Space Museum is a federal museum, everyone has a federal job title and a working title. The museum board is comprised of up to 32 members of the aerospace community. The rest of the employees are divided between three different departments. Information about the departments and responsibilities can be found in the table below. The docents formally reported to the department of education, but in mid-2019, they were moved to Visitor Services Department to better streamline the program organization and utilization.

Programmatic and Educational Offerings

The Air and Space Museum provides various educational opportunities, both on and off-sight. The website has an entire page of virtual games for students that covers various air and space topics, including how things fly and space. They also offer previously recorded programs and read alouds of a variety of famous books. The Air and Space Museum has an active YouTube page that supplies information on various topics related to stories of exploration, innovation, and discovery.

Before COVID closures, the museum welcomed field trips daily. During the COVID shutdown, the museum offered virtual field trips that live-stream various museum educators.

Every summer, the museum welcomes 30 educators from around the country to attend a two-week teacher leadership symposium called *Teacher Academy* that covers various topics from STEM integration in classrooms to science content.

SHE Can STEAM Summer Camp works to increase the number of females, the Smithsonian offers a week-long camp in either Virginia or Arkansas for girls from title one schools who want to learn more about STEM and STEM careers. Smithsonian educators host this experience.

The museum has created week-long lesson plans covering a range of topics from Artemis and Science Fiction to Bee Keeping and Spacesuits. These guides are completely free and provide teachers with a lesson template, resources, and virtual labs.

Tasks, Roles, and Responsibilities of Educators

Educators within the National Air and Space Museum are responsible for various tasks within the facility. As Neil Johnson said, "We are in charge of everything from A-Z." Johnson said, "guests expect there to be content experts when they arrive at our institution, and most of those experts are the educators." Some educators work to learn new information and become content experts in particular areas, such as World War Two planes or Astronomy. Other educators, usually more entry-level, are responsible for designing new programs and experiences. Johnson shared, "around 10% of our programs are geared towards schools. All other programs are geared towards any guest that visits our museum." One thing the Air and Space Museum did that I found interesting was "pocket science" experiences. They would position educators strategically around the exhibit floors with one-to-five-minute demonstrations. These educators could interact with hundreds of guests a day with short, interactive experiences. The museum chose to use this model to afford more guests the opportunity to interact with educators.

Educators at the Air and Space Museum are also responsible for finding standards and creating content to surround them. They work with teachers and national sponsors to develop programming aligned with state standards and air and space. A few examples of programs include "How Things Fly" and "Soar Together". Often, a sponsor will approach the museum and share their target audience and outcome. The museum educators will develop programs or exhibits that support the intended outcomes through digital resources, labs, and programs. They also develop and provide teacher professional development opportunities that may correlate to an exhibit or experience and connect to a specific standard they are covering within their classroom. Johnson shared they have a “massively large national following, but a minimal local following” regarding teacher professional development. He also feels the educators on staff must be incredibly flexible because most schools do not notify the museum they are coming.

Educators View on their Roles within the Museum

According to Michael, educators view themselves as visitor advocates. “We know what it is like to be a learner, and we understand what learners need to succeed, so our voices should ring the loudest when sitting at a table with museum staff from other departments. Educators should have a deeper understanding of learning theory as well, so we know best practice.” Another interesting thing Neil discussed was the positioning of educators in importance.

> Most of my educators would tell you they felt they were at the bottom of the ‘pyramid’ of important people within the institution. When a visitor comes, they will always interact with something relating to visitor services and even facilities, but they don’t always directly interact with individuals from education. Educators know their role is critically important to the mission of the institution. What we do is like the sugar on top of the cornflakes. Due to the size of the collections and research department within our space, they drive the vehicle. But we play an incredibly important piece to that puzzle.

Educators expect themselves to be content experts. When visitors ask a question in the World War Two Planes exhibit, the expectation is that the educator available there will know the answer. “They expect that from a place that is a National Museum. We should be the experts.”

Perspectives of Commonalities between Educators

The most important thing Neil looks for when hiring an educator is experience. “Because we are such a well-known place, people expect to come in the door and immediately interact with an expert. I prefer someone who at least has experience with engaging an audience. I can teach them the science.” Beyond experience, Neil looks for people who know more than just theory, are familiar with various audience types, and can be outgoing. He feels people need to be outgoing because it is their responsibility to engage the guest. Enthusiasm was the final character trait he listed. He mentioned the importance of engaging and exciting anyone from “ages 8 to 80” in anything related to air and space practices or history. “We expect our staff to be good actors.”

Gauging Effectiveness in Educating the Public

The National Air and Space Museum utilizes assessments primarily to determine future changes and prove important to donors and stakeholders. The museum's practice is to use attendance and hold time to observe active engagement. “The average hold time in one of our exhibits is around seven minutes,” shared Johnson, “If a family stays in the exhibit for 20-30 minutes, we know they were engaged. Due to a smaller-sized staff for the institution's size, Johnson said assessment is not always on the top of their priority list. “We try and get data when we can, but we need more assistance to do it effectively.” One new practice is to tie educational assessment to funding requests. We clearly explain to the donor what information we hope to gather or observe and layout, in detail, the evaluative measures we will utilize. This creates built-in evaluative tools that automatically detail if we effectively educate the public. The museum also utilizes observation as a powerful assessment tool. Johnson said, “We look for longer-staying visitors. Longer staying visitor’s equal engagement to our team.” He opined the exhibits with the longest holding power look engaging as people walk up (lights, colors, sounds) or are on topics that are being discussed currently in society.

Effectively Communicating Science with the Public. There are several practices the Air and Space Museum utilizes to ensure they are effectively communicating science to the public. They believe there should be some utilization of scientific terminology, balanced with demonstrations or easier explanations. “We use the actual words we want them to learn, for example, thrust, but we make sure to include pictures, answers, explanations, or descriptions to make that information stick." Another practice is to identify previous background information by asking some basic questions. "We know if someone comes to us with some sort of knowledge by the way they talk to us. The best question we can ask is 'what brings you here today?'. That answer almost always gives us a good guess on their interest level and previous knowledge." Johnson shared. If a guest has no working knowledge on a topic, the educators are trained to start from the basics before working to the more complex. "Our educators work incredibly quickly to ensure they find out what the guest knows, any misconceptions they have, and anything they are interested in. We may only have five minutes of face time with them, so we want to make sure it's worth their time!" Finally, educators work to encourage critical thinking using the engineering design process as an exemplar. Instead of providing answers, they model scientific thought from the initial brainstorming to the trial. "There may be a right or wrong answer to a question, but we want them to arrive at that conclusion."

Building Programming and Outreach

To be planning programming and outreach focus, the education team gathers and uses a brain dump to throw many ideas on the table. Once they have brainstormed various ideas, they work to answer questions such as Who is our target audience? What are their needs? Which program would meet those needs? Once they identify the focus groups they are targeting, they begin planning strategic programming and experiences to meet those predetermined needs. Because such a small focus of their programming is educational, the museum doesn't include every lesson's standards. The educators also create programs and experiences that support the exhibitions in place. Because the exhibition hall has not been changed since the museum opened, the educators work to keep the programming changing to engage visitors if they visit more than once.

Additionally, the museum works to create programming to fit current events or famous anniversaries in space and flight history. For example, in 2017, the museum developed a number of programs focused on eclipses because of the famous solar eclipses. A few examples of programming included planetarium presentations, giveaways of telescopes and eclipse glasses, and eclipse programming on the National Mall lawn. Another example would be the programming push to educate individuals on the 50th anniversary of the Apollo Moon Landing. Audience needs and museum collections often are the main drivers in determining future focus. Because the exhibits themselves don't change usually, the educators find new ways to teach about existing exhibitions.

Conclusion

After completing these interviews, it was apparent there was a thread of similarity between educator roles at informal science institutions. These positions were an important face of the institution, as they are often the only individuals' visitors interact with, outside of customer service needs. Educators create and provide programs and outreach to match the institutions mission, vision and specific needs. We know that informal science educators play an essential role in the museums, zoos and science centers they serve. However, I was interested in exploring the commonalities between those who work at a variety of institutions and gaining information about educational decision-making processes better to understand the landscape of informal science educators. Subjects for the study were identified through snowball sampling. In two cases, the initial person at the institution I contact recommended someone who may better address the issue central to this study. I initially contacted 15 individuals and was able to complete interviews with eight yielding a response rate of 53%. This lower-than-expected response rate is assumed to be due to the ongoing COVID19 pandemic. Individuals responding to my request included zoo, science museum, and science center, educators.

Chapter V: Conclusions, Discussion, and Implications

This chapter includes a discussion of the five research questions based on the data revealed throughout this study accompanied by five cross cutting conclusions regarding life as a museum educator. This chapter concludes with four recommendations for informal science institutions and several recommendations for further research.

Analysis

***Research Question 1*: How do informal science educators view their role within the institution's environment?**

When asked about their role within the institution's environment, everyone with whom I spoke, whether an educator or supervisor, was very clear they knew they made a difference. "Our people impact every visit, whether a visitor ever even lays eyes on them . . . they set the tone for the experience." shared June Gates of the *Detroit Zoo*. There appeared to be an obvious sense of role and impact and pride in the work they did.

Within the interview, two questions focused on educator and leadership opinions on the role museum educators play and three themes emerged related to research question number one. The themes relate to the perception of the importance their position plays within the museum, their confidence, and their role in teaching museum visitor to be critical and analytical thinkers. The table below includes specific quotes about museum educators' views on their positioning within the institution's environment.

Table 4

A Summary of Educators' Stated Positions within the Institution

Institution	**Viewpoint**
Michigan Science Center	• Vital to the success of the institution • The bridge between formal and informal education • Inspire lifelong relationship with learning
Detroit Zoo	• Impactful • Engaging • The face of the zoo
Dallas Zoo	• Audience advocates • Responsible for bringing science from behind the scenes • Conduit between science and the public
Perot Museum of Nature and Science	• Touchpoint for staff and visitors • Essential to the overall success of the museum
National Air and Space Museum	• The critical piece in the donation process • Critical to the role of the museum • The connection between collections and floor
Tulsa Discovery Lab	• Creatives • Overseers • Engagement specialists

Each subject had strong feeling that they, as educators, played a vital role in the institution's success, and without them, outreach would look more challenging and less engaging. The pride educators felt when describing their impact was palpable. Kirsten Call from the *Smithsonian* said, "We are the most important people in the building! Whether people will voice that or not is up for debate, but there is an understanding that the education department is the cog that keeps the whole thing moving." All individuals interviewed recognized that their department (education) was vital to the institution's success and shared they could not be successful without other departments, such as facilities and operations. I feel that a shared sense of responsibility ensures the institution moves forward.

Another shared view between these educators is an understanding of stakeholders' opinions and expectations even if the stakeholders were described differently by each institution. Some institutions, such as the *Dallas Zoo* and the *Michigan Science Center*, felt stakeholders were best described as board members or individuals who were not employed at the institution but may have a powerful voice in program development or fiscal decisions. Their boards had substantial reach and could request specific programs or monetary decisions, including directing the educational program. Robert Graves director of the *Tulsa Discovery Museum* shared

> One of the main ways we brainstorm new programming and outreach focus is through strategic meetings with our board and stakeholders. Their interests often determine where they are willing to put money and time, so we try very hard to remain true to our mission and vision and the role they play within the center. We have had to redirect and change board members ideas and requests on occasion, but they acknowledge and understand educators within the center may have a better idea of what is needed.

Other institutions, such as the representatives from the *Perot* and the *National Natural History Museum*, described stakeholders as upper administration. These museums seemed to have less contact with the board, explaining why the board was not considered a stakeholder. Raymond Claire from the *North Carolina Museum of Life and Science* felt the board needed to be held to certain expectations.

> Often, when museums allow boards to have too loud a voice, it creates an identity crisis. They end up with exhibits and programs that aren't true to their mission and vision but are of interest to a certain donor. That is not what we want. We want the board to provide oversight and advice, but also to understand that we employ very talented individuals who are more than capable of creating their own experiences. If a board member has a specific interest and wants to talk about how it may fit within our institution, I am always willing to meet. When I first arrived, the board had significantly too much reach, and it was felt. We did so many things that didn't tie back to anything but were board-driven. We made the distinction to set the development team as a natural barrier between the board and the museum staff. We trained the development team on how to answer questions or drive ideas, which has drastically decreased the number of requests we receive.

As observed, stakeholders play quite different roles within institutions but are often vital to the process. June Gates with the *Detroit Zoo* felt one of the responsibilities of upper administration was telling the education department's story well enough that they trusted them to make right, informed decisions. “How do they know we are of value? I tell them!” Gates stated. It appeared boards with individuals rooted in the field had a louder voice than boards with prominent businesspeople from the community. Regardless of whether they defined stakeholders as upper administration or board members, all felt their positions were appreciated and respected.

Organizationally, informal science centers were structured differently. In today’s world, most museums are organized by three distinct areas: administration, assets, and activities (Lord & Lord, 2009). At most places interviewed for this study, education was supervised by a member of the executive leadership team. Literature also shared most docents and volunteers were housed in the educational department. This was not what I found throughout my interview process, as several places housed their volunteers in the administration department.

Educators as the “Face of the Institution”

Falk (2002, p.63) reminds us that, “Research suggests that nearly half of the public’s understanding of science derives from [the informal and free-choice learning] sector, which supports the on-going and continuous learning of all citizens”. This statistic highlights the importance of informal science experiences as being fundamental in all people's educational process. While informal science center learning is vastly different from formal classroom learning in that it is self-guided and unpredictable (Hopper-Greenhill, 1994), the experiences can play a large role in understanding a challenging concept or topic.

Most of these educators, when asked about their impact within the institution, quickly shared the position they hold is a vital role in the institution’s success. One of their main responsibilities is ensuring programs and experiences are engaging. June Gates, from the *Detroit Zoo*, shared, “when people leave our facilities, they won’t remember much, but they will always remember something that made them say ‘ahhhhh’ or ‘wow’.” For many groups, Stephens with the Perot stated, “educators are the only interactions they have with actual staff. It is our job to ensure they are feeling seen and represented.” While employees who work in facilities or membership services may never interact with a guest, the museum educator will have some interaction with them, whether directly or indirectly.

The *Detroit Zoo* uses the educator’s role to encourage collaboration with various nonprofits throughout the community. For example, they partner with scientists working to improve their science communication skills by utilizing the zoo staff to provide training and development. Their staff provide training on effective elements of science communication and then provide an opportunity for them to practice their new learning on zoo visitors. The educators at the *North Carolina Museum of Life and Science* represent the museum within the walls, but when they can engage with the public, working to form partnerships that will draw visitors to the institution and model scientific thinking for participants. “When guests interact with our educators, whether on-site or in a school, they should leave thinking ‘that place employs people who care.” Claire shared the feeling people have when they leave a place will stick with them for a long time and is responsible for getting people back in the door again. Non-profit organizations, including schools, can be vital to an institution's success, so they must ensure they have positive interactions. According to Graves, these partnerships drive visitors, curriculum and content development and tell the institutions story better than they can sometimes tell it themselves.

Tran’s (2008) findings were all supported by the interviews conducted. Educators reported often being the only individual to interface with visitors outside of the ticket counter. Neil Johnson shared the education department often take responsibility for encouraging partnerships and collaboration with other departments. Morgan Rye continued the zoo works to create partnerships outside of their gates with other organizations, such as Scout Troops and other nonprofits.

Meeting Visitors at Their Level

Another role museum educator’s take seriously is their responsibility to ensure visitors learn something new through the utilization of conversation. Every educator interviewed mentioned the importance of quickly assessing a visitor to determine their background knowledge and then build from that beginning. They all discussed, some at length, that visitors need to feel successful when visiting their institution. “If we do our jobs correctly, visitors leave feeling positive about what could be viewed as an intimidating experience,” shared Call with the *Smithsonian*. She said “we have a strong responsibility to serve every person who walks through our doors. Sometimes that means working to be overly engaging, which means breaking down even the simplest concepts. Every person is our responsibility.” It was apparent the weight of that responsibility was felt equally among institutions, as they each shared the importance of welcoming all people, regardless of background and experiences. The educators believe a large part of their responsibility is to create engaging programs that can be made easier and more challenging to ensure all people walk away from learning something. “For some people, we are working to explain the complexities of a chemistry equation, and for others, we are modeling how a good audience member acts. Both jobs are vital to the museum's success.” shared

Raymond Claire. Claire felt the differentiation between explicit science and the ability to be an active participant in science education were both important goals.

The diversity in informal science institution learners was highlighted in the hiring practices shared with me. Esther Park shared that over 50% of their educators have theater or performance backgrounds. “When we look to hire someone, we don’t care if they have a science background. While it’s nice, it is not required. We want people who can be engaging and influential, make guests feel welcomed and valued, and work as a team...science can be taught. People skills cannot!” Several institutions shared the same feelings and had very flexible hiring practices if someone was able to explain something well, regardless of the institution type. Caitlyn Stephens put it best.

> When I am looking to hire someone, one of the last questions I ask them is their formal learning background. I want to know how science made them feel as a child. I want to know how they work with others. I want to know what soft skills they bring to the table. We are happy to teach the content. My best workers are people who struggled greatly with science as a child. They can now describe and explain things better than anyone else because they come from that place of being a learner. Those are skills you cannot teach.

Teaching Visitors to be Critical and Analytical Thinkers

Educators also seemed to pride themselves on having responsibility in modeling for visitors on how to think critically and analytically for themselves. “We can tell people what we want them to hear, but if they don’t know how to find information for themselves or determine whether something is a credible force, we haven’t done our full job,” shared Raymond with the *North Carolina Museum of Life and Science*. Each educator I spoke with felt very passionately about the role they fill because not only do they make challenging content and material understandable, but they also advocate for the audience. The educator from the *National Museum of Natural History*, Kirsten Call said, “Our largest and most important role is that of audience advocate. What do they want to experience? What do they not understand? How can we make it more understandable?"

These educators' model scientific thinking and analytical thinking through the questions they ask, the discussions they hold, and the material they cover. Call, with the *National Natural History Museum,* shared they ask questions about not only things visitors may have learned, but work to tie it back to their daily lives. "We want people to be able to take something away and apply it to their life at home. Washington D.C can be so overwhelming, so we want them to walk away with a tangible application." Guiding someone through the learning process from start to end, these individuals have a window into their thinking and best make connections to real-life learning. Claire of the *NC Museum of Life and Science* shared

> We want visitors to walk in and have an experience with science, but we also want them to take away an understanding on how to view a piece of scientific information and make a decision on how to best digest it. In America today, we see an issue with a scientifically illiterate society. We see it all the time. People come in with biases and misconceptions and wrestle with replacing that understanding with new thinking. If we can model how to do that . . . how to acknowledge there may be more than one way of thinking about something, we have changed a life.

He explained that with the current nature of science, it is more important now than ever to model how to be critical and analytical when you are approached with information.

Overall, the educators interviewed appeared to understand the importance they played within the institution's structure and knew their roles were vital to ensuring community engagement. The shared identity found highlighted the variety of backgrounds educators had, but also the pride they had in creating unique opportunities for guests.

***Research Question 2:* What were the responsibilities of individuals classified as science educators?**

This question received a wider variety of responses. The commonality found was that educators' job roles were determined by the institution they served. Some institutions, such as the *Dallas Zoo*, *Tulsa Discovery Museum*, and *Michigan Science Center*, had educators complete all assignments, from floor education to programming to ordering supplies. Other institutions, such as the *National Museum of Natural History* and the *National Air and Space Museum* seemed to have a narrower focus and divided educators between individual programs. There was not a coherent practice followed by all institutions interviewed. The most common job completed by educators included program development and offerings. Departments that had specific educators responsible for programming included family programs, youth programs, and school programs.

When discussing job responsibilities with the subjects, I learned that the educator role can vary drastically, depending on the institution type, size, and leadership. Specific job roles and duties seem to have been determined by members of the upper administration. Most institutions required educators able to work in any area necessary, which ensured they had a working knowledge about all programs and experiences. Other, often larger institutions have educators divided between specific programs, such as Family Programs, School Aged Programs, and Senior Programs. The places that organized educators into smaller, specified working groups allowed them to have in-depth working knowledge on more particular things.

Raymond Claire shared how he transformed the entire educational structure after he arrived because he observed they were too focused in the day-to-day to allow time for creativity and innovation. Through his 'Integrated Experience Model,' Claire clearly distinguished between educator's support staff.

> When I arrived at the museum, I quickly realized the education department was poorly set up. They were so focused on the day-to-day and minutia of small tasks they could not be innovative or creative. I needed my people to tackle large projects, and their brain space was tied into things that were a waste of time. I quickly knew that I had to to

> change some things to free up their time. Hiring entry-level people to join the team and take over the responsibility of making purchases and setting up for special events was an easy choice. It allowed the individuals on my team who had the skillsets necessary to sit and think and innovate.

Several institutions had educators responsible for everything from supply ordering to program design. Esther Park, of the Michigan Science Center, and one of the departments with educators responsible for every role felt it was advantageous for her staff to be accountable for every position. “When educators are responsible for the micro and macro responsibilities, they can better speak to the entire experience. They know that slime, for example, maybe needed because they are the ones who ordered it in the first place.” In table 5, readers will find the specific roles educators play within the informal science institutions surveyed. Due to the narrow interview field, these jobs are specific to the people interviewed, but may differ from other coworkers.

Table 5

A summary of Roles and Responsibilities of Educators at these Informal Science Learning Sites

Institution	**Roles and Responsibilities**
Michigan Science Center	• Facilitators of programs • Development of Programs • Live Theater and Stage Experiences
North Carolina Museum of Life and Science	• Nurture critical thinking • Creating frameworks for program design • Evaluation • Program design • Community Collaboration • Management and delivery of staff training
Detroit Zoo	• Work with schools • Create learning experiences • Design and deliver professional development for teachers • Determine and purchase supplies • Science communicator workshops • Attend and present at conferences

Table 5

A summary of Roles and Responsibilities of Educators at these Informal Science Learning Sites

Institution	Roles and Responsibilities
Perot Museum	• Training staff • Purchasing supplies • Teaching • Program development • Providing professional development to museum staff and educators
National Air and Space Museum	• Program development • Teacher PD • Content Experts
Tulsa Discovery Lab	• Curriculum developers • Provide off-site instruction in schools and non-profits • Provide museum classes • Manage the lab spaces within the museum • Order supplies
Dallas Zoo	• Facilitate educational programs • Manage youth volunteers • Camps, night hikes, and special events oversight • School programs • Preschool outreach • "Tech Truck" program (portable STEM lessons in a truck)
Smithsonian National Museum of Natural History	• Design and evaluate programs • Test ideas • Liaison between the science staff and public • Logistics and facilities for events • Help visitors find relevancy in content • Order supplies

Requirements to be Well Versed in all Education Responsibilities

The roles museum educators play determined by the institutions at which they work. The museum educator's actual work is often determined by the museum they serve, guided by their mission and goals (Ljung, 2009; Tran, 2008b). The interview responses supported this literature, as each museum had a variety of responsibilities and expectations for its educators. The first theme that was revealed by this research question was the importance of having educators well-versed in all responsibilities that fall within their program. Almost every institution I interviewed had individuals who worked with various programs. The knowledge one gains when able to flow between programs creates more organic opportunities for collaborative experiences. When an educator can find standards, design a program, and present the program, they fully understand what information is necessary and included. Educators who have an intimate subject and content knowledge can easily access misconceptions and areas that may be challenging. Neil Johnson, of the *National Air and Space Museum* shared the importance of having a deep knowledge of content that may be covered in an exhibit or program.

> We have visitors from all over the world in our museum. Some are young children whom are just interested in flying in a simulation, and others are ex-pilots or aviation hobbyists who could easily know more than me. I always take the diversity in visitors as a challenge to continue to grow within my own field.

At the *Tulsa Discovery Lab*, Claire explained they have several exhibit spaces that rotate exhibits quite frequently. They expect the educators to provide guided tours and open-ended inquiry opportunities for each guest. Knowing an extensive amount of information and the purpose behind the experience makes it easier for the educator to answer questions. Raymond Claire said he prefers educators to understand science's process over the content of science. “I think one of the greatest things we can do for people is [to] model what it looks like to say ‘I don’t know, but I will find out. One way we make it OK for educators to say that is by allowing them to be a part of the entire process from brainstorming to execution which creates a buy-in that we cannot force.” This process happened through an initial think-tank where the museum brought several educators and others who may physically build the exhibit or the content found within a permanent structure. From there, Claire has cultivated a culture where individuals feel comfortable providing ideas.

Flexible Characteristics of Museum Educators

Another common thread between each education department I interviewed was flexibility in hiring educators. More than one institution shared they would rather someone be dynamic than have a background in science because they can teach smarts, they can not teach engagement. At least two institutions hired individuals with theater backgrounds. Esther Park shared, “They make great presenters. They are willing to engage with the audience and can interest them in a topic faster than anyone. I am always willing to teach [them the] science. You can not teach the people skills.” *The Dallas Zoo* also employed many nontraditional backgrounds, most of whom held backgrounds in theater or performance.

Employing nontraditional people, individuals not trained in science or education, is the goal, shared Esther Park.

> We are informal science educators, so one of the benefits of having broad hiring allowances is the ability to look for people with nontraditional backgrounds. While we love employing traditional educators, there is something about the childlike qualities that we can most easily find in people with different professional backgrounds. We are all kids at heart which makes this experience that much better. We know what kids want to see because we have a child-like heart ourselves.

I also was surprised to find how many of these educators listed their preference for a variety of problem-solving skills or people skills over specific academic preparation. Each institution I spoke with felt they could train someone formally, but they cannot teach inherent people skills. Because educators are the face of the institution and carry an enormous burden of ensuring visitors leave feeling represented and welcomed, people skills take them much further than deep scientific understanding. Park went on to share

> We can always teach someone how to, for example, create an elephant toothpaste demonstration and build a show around that. What is significantly more challenging is working on teaching people how to make a connection or put someone at ease when they are feeling uncomfortable.

Finally, employees must be good team players. “Nothing we do in a museum is in isolation. Our educators are always partnered with at least one other person”, Stephens shared. Ensuring educators have the skills needed to collaborate and compromise makes every process more manageable. Gates shared about that.

> We are a team amongst ourselves . . . the education department. I need each person on that team to have equal buy-in and interest in whatever we are doing. I also need them to trust each other and the process to make our efforts work. Beyond the education team, we have the entire zoo team. Not only are we working with them to create bigger programs and events, but we always must be telling our story. Collaboration is what makes what we do work. We collaborate with each other, the bigger zoo staff, and the nonprofits we partner with on an almost daily basis—nothing we do works in isolation.

After completing my case studies, I learned that none of the informal science centers investigated for this study have specific requirements for educators. One of the most important things they look for is soft skills and personality fit. “We want to make sure the person we are hiring can help fill in some of the areas we may be weak,” said Stephens. “I can hire 15 people who are good at one thing, but if they can not do anything else, they aren’t of much help to me.”

***Research Question 3:* How did informal science learning sites determine their educational programs and outreach goals?**

Programmatic and outreach focus seemed to be determined by three factors: the personal interest of the staff, funding opportunities, and current events. I was surprised how strong individual education staff interest drove programming decisions. More than one institution interviewed shared they ask staff what they are interested in and use it to determine new offerings. A few institutions shared funding drives most of the decisions they make. If they can find a grant that will fund a specific topic program, they are more willing to create something on that topic. Board members often will willingly support a plan if the subject is of personal interest. Finally, current events provide a good launchpad for new programs.

Each institution where I interviewed an educator on staff seemed to share a similar methodology in determining programmatic and outreach focus. I found it interesting that each person mentioned the board and their interests at least once when explaining how they determine the museums' direction. More extensive facilities were able to dissuade board members from driving ideas more easily. Additionally, the smaller institutions seemed significantly more focused on the schools' needs and non-profits located near their institution. The Smithsonian representative never mentioned utilizing schools near their facilities for feedback, as Call referred to them as “American’s Museum.” “We know we only draw from a small amount of locals and the large sum of our visitors come from out of state. Below, in Table 6, is information on how the institutions interviewed to determine their programmatic and outreach focus.

Table 6

Programmatic and Outreach Focus

Institution Name	Programmatic and Outreach Focus
Michigan Science Center	• Must support CEO's 5-year plan • Must align with museum mission and vision • Famous anniversaries in STEM and science
Detroit Zoo	• School requests • Must be focused on living things • District needs
Smithsonian National Natural History Museum	• Highlight the current work on the science researchers employed at the museum • Science process • Highlight collections on hand • Showing representation in science
Perot Museum	• Standards and alignment guides • Interests of staff
National Air and Space Museum	• Initial idea generation meeting • Determining Audience Needs • Funding
North Carolina Museum of Life and Science	• What is the team interested in? • What is the community interested in? • Geographical location interests • Nature ties
Tulsa Discovery Lab	• Staff enthusiasm • Stakeholders opinions • Analysis of programs most frequently booked • Response to solicitations for funding
Dallas Zoo	• Front-end evaluation results • Partnerships that could equal additional funding • Educational needs of nearby students

Another trend identified by reviewing the individuals cases was the personal power interest in the brainstorming process. Several institutions allowed educators to present ideas based solely on personal research interests. They did not allow every program or event created randomly, but they did play a significant role in the design process. Raymond Claire, from the North Carolina Museum of Life and Science shared, “I enjoy my educators using their interests to drive creation. When they are personally interested, they are always more personally invested in the outcome.” The other significant determining factor for programs and outreach is the schools' personal needs around them. Most of the institutions shared they have someone on staff with an in-depth knowledge of content and standards followed by the schools in close vicinity. Morgan McDaniel said,

> We want to make sure our programs align with the standards teachers are responsible for covering. They already have a hard time explaining to the administration why they may come to a zoo, and they don’t need it made harder by us throwing together a random experience. Our job is to help educators justify why we should be an experience they provide.

School Partnerships Matter in the Work of Museum Educators

The first theme that emerged with respect to this research question linked to weight museum education departments place on educators’ opinions. June Gates of the *Detroit Zoo* shared the opinion that teachers' requests are the number one factor they consider when creating a new program or experience.

> We value what teachers have to say and want to ensure that their time spent with us is valued. If they feel it is a waste of time, they are less likely to advocate for a trip in the future. The most incredible sell we can give our board members is a teacher's testimonial from the impact a field trip had on their students.

When designing new programs or experiences, educators review state teaching standards, state end-of-year assessments, and the evaluation comments that teachers left on previous encounters. The contact at the zoo also shared that when teachers are given a role in the design process that encourages them to return and engage in a way that is helpful to the museum and students.

Those school partnerships were discussed by six of the individuals interviewed. They rely on the field trips as a revenue-generating opportunity and teachers for providing feedback. Each person who spoke to me about school programs expressed an understanding that field trips are declining. Robert Graves explained, “We have to work even harder to get kids in our doors nowadays. We are competing against budget cuts, state testing requirements, and increased class sizes. Those are hard things to overcome.” The best programs are those designed to fit schools' needs; this automatically increases the likeliness that schools can easily justify the expense of a museum visit.

Falk and Dierking (2019) found children spend only 20% of their time in schools, so free-choice learning is instrumental in their education. Informal science centers, such as zoos, museums, and science center's supplement formal education by employing educators and educational departments and providing various experiences. Educators directly impact the understanding of complex topics and can clarify misconceptions almost immediately. Through interviews, I also found partnerships are frequently built between visitors and institutions, ensuring they return for more than one visit. This partnership provides exposure to science concepts repeatedly.

Creation of Programs and Outreach is Best When a Collaborative Process.

Each museum representative listed the word “collaboration” or “collaborative” when discussing important practices. “Collaboration allows for an equal buy-in for all members of the team.” Parks shared. When museums are creating new exhibits or programs, the collaborative process compiles experts in the content area and education to cover what is needed and utilize best practices. When the *National Natural History Museum* created a new exhibit, Kirsten reported that they brought together experts on that topic, including scientists on staff and educators. From the initial planning meeting, these individuals shared ideas and asked questions that made the design process significantly more straightforward. Including research scientists on staff was helpful because they could tie a new exhibit to the research they were currently doing.

Collaboration is also essential when viewing survey results and feedback. Several of the institutions have meetings with various staff members when reviewing assessment data to discuss ways to make changes in the future. Esther Park said, "having educators at the table with other departments is incredibly important because we may have a better understanding of how to present things, but other departments may have a better understanding of logistics within the facility or the science behind something." Those team meetings create a place for all departments to hold a stake in what is happening across program areas.

The Varying Impact of the Museums' Governing Board on Education Matters

The institution's board role was something I found interesting. Each institution shared the same experience: unless you are senior leadership, you will probably never meet with or interact with the board. One unique thing I learned was that the board's role could vary drastically from institution to institution. Some allow the board to have a very loud voice in the design and creation of new exhibits and programs, and some work very hard to ensure the board does not play a role in the idea generation process. Smaller institutions, such as the *Michigan Science Center* and the *Tulsa Discovery Center*, reported a larger role for the board. I believe this is because their board is more easily accessible and the pool for brainstorming is smaller. At larger institutions, such as the Smithsonian, there are so many personnel layers between educators and the board they may never meet them. In these smaller institutions, educators are much more likely to interface with the board. They allowed individuals on the board to propose programmatic and exhibit ideas, especially if they had the funding to provide. One example was a frog exhibit at the Dallas Zoo. A board member had an immense interest in Panamanian frogs and was willing to fund the creation of the new exhibit, so the zoo made space for this. Another institution created an exhibit focused on Nikola Tesla because of a board member's interest. They were able to connect the exhibit to the museum's institutional focus, so the addition of the exhibit was only additive to their goals. The board member funded the process, so they were happy to include the new exhibit. This proves money plays a big role in the decision-making process for future exhibits and programs.

Larger institutions, such as the *North Carolina Museum of Life and Science* and the *American Museum of Natural History*, provided educators little to no interactions with the board. Kirsten Call explained,

> Our board at the National Natural History Museum is comprised of a lot of very high-profile individuals. The board was just another thing they did. While they were able to bring a lot of attention to our institution and find unique funding opportunities, they did not play a role in our day-to-day planning and operations.

Raymond Claire shared one of the first things he did when arriving at the *North Carolina Museum of Life and Science*" was work to create separation between the board and the educators. "We worked to implement a process where the board had to filter all ideas through our development team. This drastically limited the random ideas they shot our way and allowed us to decline their suggestions without offense easily." I feel this was a clever way to filter out the ideas that had no tie to the institutions vision and mission and provided boundaries for the board.

Table 7
Board Members' Role in Educational Decision Making

Institution	Board Role
Michigan Science Center	• Looking to grow the board to increase input (COVID caused severe decrease in memberships) • Infrequent interactions • Will come to visit if they are connected to a donor of a specific project • Will provide feedback and suggestions • Working to make it more challenging for them to provide ideas easily
Detroit Zoo	• Consistent interactions through brainstorming meetings • Works hard to answer "How do they know we are of value" • Comprised of 15 separate committees • Anticipates concerns
Smithsonian National Natural History Museum	• Priority projects will get you to face time with the board • Meet only twice a year (Board comprised of high-power people) • Consistently push back that the museum should tell "America's Story"
Perot Museum	• No interactions with the board
National Air and Space Museum	• Infrequent interaction with a board (full of "celebrities")
North Carolina Museum of Life and Science	• Comprised of committees (none on education) • Passive board (not currently working) • Rarely have ideas on programming
Tulsa Discovery Lab	• Monthly Meetings • No real impact on educational decisions
Dallas Zoo	• No interactions with the board

***Research Question 4:* How did these informal science institutions communicate science with the public?**

Communicating science with the public is the priority for each education department I interviewed. The set of standard practices used includes a variety of soft skills, such as quickly forming relationships and describing complex topics using simplistic terms. Each institution expressed the importance of rapidly engaging learners through hands-on experiences and interactives to increase staying power. The repeated theme throughout each interview was the importance of making science accessible and applicable to each visitor.

Effective communication was a challenge mentioned by representatives from all institution involved in this study. Similarly, each institution approached science communication, acknowledging that if they do not hook the visitor from the start, their job becomes much more challenging. When someone is engaged, they are more willing to ask questions. Caitlyn Stephens shared their education department believes, "Questions are sexier than answers. We should be asking questions and modeling for guests how to ask questions. It is OK to leave not knowing everything...that is how we engage people in science beyond our walls." Table 8 highlights short statements from each subject on engaging the public in science and science communication.

Table 8

A Summary of Ways these Informal Science Institutions Engage the Public

Name	**Science Communication**
Michigan Science Center	• Work hard to spark curiosity • Relating things to real-life topics • Teaching science to see the world around you
Detroit Zoo	• Engage, engage, engage • Understand what they already know
Smithsonian National Natural History Museum	• Allowing them to figure things out themselves • Hands-on, interactive options • Contextualize science to make sense in their world • Finding a way to make science "stick"
Perot Museum	• Working to make all feel welcomed • Finding something everyone knows • Engage in a way that feels inspiring and accessible
National Air and Space Museum	• Age-Appropriate Language • Still utilizing the scientific vocabulary • Encourage critical thinking
North Carolina Museum of Life and Science	• Hooking the audience • Being a good storyteller • Using inquiry
Tulsa Discovery Lab	• Effective marketing from the start • Quality programs and products • Ensuring a good experience • Asking questions
Dallas Zoo	• Meeting them at their level • Looking for interests and starting there • Making it relatable • Steering clear from challenging science vocabulary

Educational Goals are Best Achieved by Meeting Visitors at their Comfort Level

Attempting to link guests with current science content has been a mostly successful practice by all educators participating in the interview. Kirsten Call, from *the Smithsonian National Natural History Museum,* spoke about that phenomenon.

> We work to create exhibits that represent what is happening in the world around us. If our visitors come in and see an exhibit or program on a topic they may have read about in the newspaper or seen on the TV, they are instantly more invested. We want to not only model scientific thinking but show that science is all around us and impacts all of us!

Using relevant topics allows guests to feel represented because something impacts them. Caitlyn Stephens shared, "we have to work extra hard to ensure our underserved and underrepresented populations feel seen within our walls. There is a natural disconnect with that population already, so we must work doubly hard to ensure they find something, anything that represents them." Other subjects shared the importance of creating an environment that served all people, regardless of color, creed, or socioeconomic background.

Education departments must also closely work to quickly assess people regarding previous knowledge and misconceptions shared Kirsten Call. "We only have people for a short moment in time, so one powerful strategy we use is asking questions. That short response guides the rest of our conversation." That knowledge provides a launching point for the educator and can provide insight into where to guide people and what necessary information they may want to learn more about. Morgan McDaniel shared, "If people are interested in marine life, we are going to make sure to direct them to one of our aquariums and share any programs we may have on that topic. Creating that personalized experience can make all the difference in the world."

The Impact of Curiosity on Holding Power

Each subject interviewed voiced the importance of encouraging curiosity and innovation in program and experience development more than once. Esther Park said,

> What we do has to be creative and unique. There are many competing forces for people's attention, even the cell phone in their pocket when they walk through our door. If we can catch their attention within the first few minutes and spark a bit of curiosity, we know we have them.

When visitors are curious about something, they naturally want to learn more, which greatly works in the informal science institutions' interests. Robert Graves felt informal science learning places could be consistently more “curiosity-focused” than formal classrooms due to size, layout, structure, and time. “We aren’t taking a standardized assessment at the end of the year, and we aren’t tied to a specific set of standards. If a guest is interested in something and an idea sparks, we have time to walk them through that thought process.”

“Questions are better than answers” was a theme reported by two different people. As Raymond Claire of the *North Carolina Museum of Life and Science* said

> We want guests to enter and instantly begin to wonder things . . anything . . . just something. We want them to look at something and say, ‘I wonder how they did that!’ But we also work continuously to train our staff that they should not only be comfortable asking questions and being curious, but they should also be actively modeling it on the floor. Curiosity plays such an important part in the scientific design process, and we want our staff to be at the forefront of that process. Questions are always sexier than answers.

Kirsten Call also explained, in-depth, how in-house scientists and a massive collection can organically lead people to curiosity. “Our institution, by nature, is large. We have something for everyone. Housing scientists, who actively conduct research can be massively engaging because who doesn’t like to watch the person behind the glass? You instantly say, ‘I wonder what they’re doing.’ That moment is how we know we have them.”

Modeling curiosity is a shared expectation. “We don’t want our staff to know everything. We want them to be able to look at a guest who asks a challenging question and say, ‘I don’t know, but I bet we could find out!’ Parks shared. “That dialogue model something for the guests that no exhibit or program can model better . . . that curiosity and question-asking is good, and everyone should do it!”

Research Question 5: **What did informal science educators do to ensure they educate the public?**

Adhering to the Mission of the Institution

Each institution interviewed spoke at length about how important it is to adhere to the institution's mission and vision when creating programmatic offerings. “We have to remain true to the goal of our institution in everything we do. That is the first step in ensuring people will be engaged when they come . . . if they come to a zoo, they want to learn about that topic. If we [develop] an exhibit on cars, unless they magically fit, it wouldn’t make any sense.” shared June Gates. Always looking back to the institution's mission and vision assures the programs and experiences line up with the end goal.

Raymond Claire, from *North Carolina Museum of Life and Science,* felt one could drastically increase the likelihood of gauging interest if staying aligned to the objective.

> I work to make sure our team is always looking back at the goal and objective of any project we are doing. Our main aim as an institution is to ‘nurture critical thinking, so I constantly push back on my staff to ensure everything they make points back to the importance of being a critical thinker. To be successful and engaging, we must guarantee our emphasis is on scientific thinking and scientific processing skills and less focused on the actual scientific content.

Remaining aligned with the institution's goal and having a clear benchmark for those goals ensures educators are aligning with the mission. Most institutions interviewed were able to identify the models or frameworks they used to align their work. I discovered smaller, more local institutions tended to utilize the schools' standards around them. For example, the *Dallas Zoo* utilized the TEKS standards to create programs and gauge effectiveness. TEKS are the Texas State Standards educators utilize when creating curriculum and content. Museums that draw a broader audience, such as the *National Air and Space Museum* and the *National Museum of Natural History,* created their own content and curriculum with which they follow.

Each institution was asked to share the evaluative tools they utilize to create assessments. Five of the institutions used the Harvard PEAR tool (Figure 2), which certified educators as evaluators and provided basic rubrics and informal science assessment frameworks. At the time of the interviews, the *American Museum of Natural History* was working on creating its framework through a grant with the National Science Foundation. Raymond Claire with the *North Carolina Museum of Life and Science* created a "Framework for Critical Thinking" to highlight the institution's top-line objective of "nurturing critical thinking." Every program and experience must align with one of the four skills or habits of mind included within the framework. All evaluations within the institution must also align with those standards. "Creating a universal system for our staff, regardless of departmental affiliation, to use ensured we were staying focused on our end goal.

Evaluation is a Collaborative Responsibility

Evaluations, while sometimes created by an individual or singular group, often become collaborative by the end. While creating the evaluation differed significantly between institutions, six of the facilities utilized focus groups when reviewing gathered information. Evaluation responses are often used to make programmatic updates or drive future experiences. June Gates with the *Detroit Zoo* shared, "We use evaluation data as a quick look into what we are doing and what we could change. The responses we get, especially from key stakeholders such as teachers and other nonprofits, can drive our decision-making process."

Raymond Claire spoke about that phenomenon.

> We like to make evaluation a collaborative experience from beginning to end. We work to make sure the people creating the evaluation have someone with whom share their thoughts. That person works as a 'devil's advocate' and asks questions they may not have thought about initially. Once the initial evaluation has been created and given, I try hard to gather a diverse group of people, not just from the education department, to review it. We need exhibits and facilities to know precisely what we are doing and what guests are

> saying because that is how we create extended engagement. If exhibits can see 'oh! That thing I created impacted someone on a certain level'; I know we've got them invested!"

COVID has impacted institutional operations significantly, but especially evaluation. Caitlyn Stephens from the *Perot Museum* reported that their Evaluation Department used to be run by a Vice President and had massive buy-in.

> We had an entire department devoted to evaluation and assessment, but that was one of the first to go due to the financial strain COVID created. The process of evaluation then became the responsibility of the education department. It forced us to find creative and innovative ways to not only create evaluations and gather data but also review them. This is the first time we have worked on a cross-departmental evaluation team, and it has been amazing. There have been several times I have heard people in other departments say, 'I didn't know you guys were doing that!'

It appeared to be a shared experience that teams of people would work together to review evaluations from two to ten. Top-level directors use that feedback to "sell" their program, June Gates said. "We can use feedback from assessments, especially really strong statements, to show that what we are doing is making an impact. That data sells our program to upper administration and board members and shows what is essential.

Connecting Exhibits to Real-Life Applications

Working to tie learnings to real-life phenomena is another way informal science institutions can ensure they are effectively engaging the public in science. June Gates of the Detroit Zoo shared how vital real-life application is too new learning. "We see significantly more engagement when someone can say 'wait! I have heard about this!'" When people can apply what they learn, they feel represented by the institution. That representation automatically creates more engagement.

Other educators felt it was their institution's responsibility to ensure their exhibits and programs were responsive to the science that visitors may interact with in the world outside of the institution. Kirsten Call said "individuals should be able to walk into our institution and know they will see information that represents the things that impact their lives. People trust us to provide them with exposure to topics, so we work hard to ensure that exposure is worth their time." June Gates also believes institutions are responsible for being responsive to current events and trends. "Individuals should not only get their science information from school or the news. We have to be another place [that] guests can come and be guaranteed accurate and current information."

Appropriate Assessment and Evaluation Techniques.

The final way institutions can gauge effectiveness in educating the public is by working to ensure they are using appropriate assessment and evaluation techniques. The only museum that employed an individual whose only response was assessment and evaluation was the *Perot Museum*. That position is currently furloughed due to COVIDs budgetary impact. That role was vital to the museum's mission and vision, which allowed the director to have a large voice in driving exhibit and educational decisions. Caitlyn Stephens, from the Perot, shared

> Assessment and evaluation data are vital to our success as an organization—most funders who donate what to know the impact their money made. Sharing evaluation results with these people is a way to show, through words and numbers, what change their donation caused. Having a staff member with intricate knowledge of what we are trying to evaluate allows us to ensure we are hitting the appropriate targeted metrics.

There are several different programs that museums can use to assist in the evaluation creation. All science centers and zoos interviewed shared they utilized the Harvard PEAR evaluation tool. Other evaluative tools include the Institute for Learning Innovation resources and the Reflecting on Practice, or ROP system. The RoP process was created by the Lawrence Hall of Science and contains four modules of instruction to be certified. The modules covered are Learning, Reflections and Science, How People Learn, Learning Conversations, and Objects and Design (What is Rop?). Institutions can become certified within RoP through workshop participation. With the *North Carolina Museum of Life and Science*, Raymond Claire created a

Critical Thinking Framework that highlighted four skills and four habits of mind. All evaluations tie to one of those skills or practices. The *Smithsonian National Natural History Museum* and the *National Air and Space Museum* allow educators to evaluate when the program is shared. The *National Natural History Museum is* currently working to develop an evaluative tool, with the National Science Foundation's assistance that will better streamline the evaluative process. One interesting connection was the struggle museums have encouraging individuals to complete evaluations and the idea of a “time budget (2015)” Heimlich speaks about. He said every visitor operates within a “time budget” which is the amount of time they are willing to give to an experience of visit. Museums have worked hard to ensure they are honoring visitors time and ensuring they will participate in evaluations by making them shorter, concise and to the point.

Discussion

Falk and Dierking (2019) found children spend only 20% of their time in schools, so free-choice learning is instrumental in their education. Informal science centers, such as zoos, museums, and science centers supplement formal education by employing educators and educational departments and providing various experiences. Educators directly impact the understanding of complex topics and can clarify misconceptions almost immediately. Through interviews, I also found partnerships are frequently built between visitors and institutions, ensuring they return for more than one visit. This partnership provides exposure to science concepts repeatedly.

The museum educator's actual work is often determined by the museum they serve, guided by their mission and goals. (Ljung, 2009; Tran, 2008b). These findings were all supported by the interviews conducted. Educators reported often being the only individual to interface with visitors outside of the ticket counter. Neil Johnson shared the education department often take responsibility for encouraging partnerships and collaboration with other departments. Morgan Rye continued the zoo works to create partnerships outside of their gates with other organizations, such as Scout Troops and other nonprofits.

Organizationally, informal science centers were structured differently. In today's world, most museums are organized by three distinct areas: administration, assets, and activities (Lord & Lord, 2009). At most places interviewed for this study, education was supervised by a member of the executive leadership team. Literature also shared most docents and volunteers were housed in the educational department. This was not what I found throughout my interview process, as several places housed their volunteers in the administration department.

The roles museum educators play determined by the institutions at which they work. The museum educator's actual work is often determined by the museum they serve, guided by their mission and goals (Ljung, 2009; Tran, 2008b). This literature supported the interviews I conducted, as each museum had a variety of responsibilities and expectations for its educators. Tran (2008) found museum educators to be the main point of contact for visitors because they tend to be the only individual's interaction with both museum researchers and museum visitors. When discussing perceptions of impact, educators felt their role was vital to the institution's success.

Life as a Museum Educator

Overall, the collaborative and interpersonal relationships museum educators have with other staff members seem to depend mainly on the amount of individuals employed within the institution. If the institution is a larger facility, the educators may be focused solely on one area and work with relative isolation. Educators employed in smaller institutions seemed to collaborate with a variety of individuals often, both on and off the education team. These educators came from a wide variety of backgrounds, from formal teachers to dramatic actors, but all participants interviewed felt their role was doable by ensuring they stayed up to date on current trends and worked to find professional development. The importance of creativity and flexibility were both highlighted in more than one interview. June Gates with the *Detroit Zoo* spoke repeatedly about creativity being a cornerstone for the work being done in the zoo. "I expect all of my staff to be creative. Some are born with that skill and some grow it, but they all have it." Flexibility was another large trend highlighted in several interviews. Individuals in these positions had to be flexible as schedules changed often, but their ideas were also not always chosen. "Even if someone wasn't the original idea generator of something, I still expect them to have 100% buy in" shared Raymond Claire. Neil Johnson, who had been with the *National Air and Space Museum* for over two decades shared it years to be afforded an opportunity to participate on committees, while Esther Park with the *Michigan Science Center* shared her hiring came with a predetermined committee responsibility.

COVID changed the way all facilities delivered content, forcing them to create both synchronous and asynchronous offerings. Smaller facilities, such as *MiSci* and the *Tulsa Discovery Lab* utilized Facebook lives to share short demonstrations or programs. The *National Air and Space Museum* and the *National Natural History Museum* previously created a wide database of recordings (prior to COVID) but utilized the pandemic to grow their online participation through zoom events. "We noticed people from all over the world would hop on a zoom. They may never be able to physically join us at the museum, but they could become a large consumer when offered online," Park shared. COVID also caused many departments to furlough or fire education staff. This reorganization changed the responsibilities, sometimes drastically, for the staff. The Perot Museum went from a large full-time staff of within the education department to two individuals. This restructuring caused the museum to determine which programs and outreaches were essential and which would need to be placed on hiatus for the time being.

Overall, informal science educators appeared proud of the work they were doing and excited about the future of informal science learning. Claire, with the *North Carolina Museum of Life and Science*, spoke about the intersection of innovation and exhibitory, which hadn't always been the case prior to COVID.

> COVID required us to work from home. We were funded well so we did not have to lay off staff, but we did have to find things for them to do. We realized in meeting after meeting that we were drastically underutilizing skills and talents. This observation encouraged us to completely restructure our approach to creating new exhibits and programs. We utilize things you don't regularly see in museums because we can!

Conclusions

The findings from this investigation of museum education may be summarized with several overarching conclusions.

Shared Identities Between Educators. There is a shared identity between informal science educators. They are firm in their belief that the role they play adds to the value of their institution and even though they may not hear this from senior administration, they know their job allows the facility to run smoothly and creates memorable experiences for visitors. While specific job roles vary from institution to institution, identity of educators and opinions on impact seem to be very similar. Job responsibilities and tasks vary from place to place and are institutionally driven, determined by either the organization or some demonstrated need. Some institutions seem to have rigid responsibilities and do not change tasks. For example, if you are in charge of school-based programs that is the only thing that educator does. Other institutions allowed their educators to play more flexible roles and work significantly more with other departments.

Jobs and Responsibilities are determined by Site Size. Informal science centers could utilize this study's implications as a discussion starter on their own practices. Some institution's practices seemed more cost and human capital effective and beneficial to all. Institutions should continue to determine the best organizational structure for their people. Approaches that worked at some places would not work at others. Other sites could benefit from restructuring their staff to make them more streamlined. Employees should work to collaborate with other departments within their organization. Education appeared to be very isolated at most places, and those individuals could offer significant advice and suggestions. Educators know the visitors more than any other program, and their advice could be invaluable.

Informality of Creation Process. There are multiple ways informal science institutions determine programmatic and outreach focus. The most common method was working to create programs and outreach experiences that best support the standards of the districts' located near their institution. Informal institutions that serve larger audiences appear to utilize the national standards or norms when determining programming or experiences. There is a shared understanding that schools are a large portion of engagement and provide insightful feedback which is important to future development. Overall, the decision-making process appears to be relatively informal. Other department's decisions can be driven by board members or influential donors. Informal science centers should continue to evaluate data to gauge the impacts of their practices. Due to the COVID19 pandemic, current events should continue to drive outreach and programming. Emphasis should continue to be placed on evaluation. There are several programs already in use, including PEAR and in-house evaluations and some of the institutions in this study do not currently have a formal evaluative practice or utilize the results of assessments conducted.

Boards Varying Impact on the Institution. Overall, board members do not play as large a role as I assumed in the education department, as most institutions no longer make large amounts of programming or outreach decisions based on board preference. As a public-school educator, our school board is an integral part in our profession, creating rules and mandates, so I assumed the informal science boards would be the same. Boards appear to be a more formal part of an institution and provide financial oversight, but do not provide much feedback or direction in the day-to-day decision making. Many educators have never met a board member or been a part of the board meeting, so while they are a part of the institution, most educators believed their biggest impact was on the financial wellbeing and publicity of the institution and not on their day-to-day operations.

People Skills are the Most Important Skills. People skills are vital in successfully educating the public. While other skills, including a background in science or education, may make individuals more marketable, soft skills and communication ability were consistently the first things mentioned in each interview. Supervisors and coworkers felt knowledge could be taught, but the ability to actively engage an audience was a much more challenging skill to teach employees. Several institutions did not even list a background in science as a part of the requirements

Recommendations for Further Research

Some version of this study should be completed at an even wider variety of science museums and institutions both to see if the central findings offered here are replicated and potentially to extend the findings. As mentioned in the limitation section, this study was conducted while COVID 19 had wrought drastic changes in employment and outreach practices at every institution whose educators were interviewed for this study. Therefore, there is a possibility that some of the findings reported here are anomalous and conducting this research in the upcoming years may yield different results.

This study could be interesting if completed with entry-level educators. Every person I interviewed oversaw educators. At every institution I spoke with, entry-level educators were the first people furloughed, so due to COVID-19, I could not speak with individuals whose only job was education. While I feel I received accurate and current information, it would have been interesting to hear from entry-level educators.

Other studies should interview informal science institution visitors to determine their preferences and needs related to best practices and preferred learning.

This study should be extended to include viewpoints from upper administration. Only one individual interviewed was a CEO. Upper administration would not accurately answer every question, as some details were more day-to-day information. Still, they may be able to explain strategic planning and direction better. Additionally, this study should be extended to include multiple individuals from one institution. Interviewing multiple people would create a more complete case.

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Appendices

Appendix A: Museum Educator Initial Survey

Interview Questions

Q1: How do museum educators in the targeted institutions see their role within the museum environment?

Q2: What tasks, roles, and responsibilities are accomplished by individuals classified as educators?

Q3: How do key museum stakeholders view the current nature of museum education in the science museum environment? How do key stakeholders view the future of museum education?

Q4: How do you gauge effectiveness in educating the public?

Q5: How do you determine programming and outreach focus?

Q6: What is the key to effectively communicating with the public?

Q7: What role do museums play in society?

Q8: How does the organizational structure of your museum support education?

Q9: How do you approach designing a new program/experience/exhibit?

Q10: What role does creativity have in the design process?

Q11: How do you know an experience will be engaging?

Q12: How do you create assessments/evaluations?

Q13: How are assessments/evaluations administered?

Q14: Who sees the results of the given assessments and evaluations?

Appendix B: Museum Educator Supervisor Survey

1. What characteristics do you look for when hiring a person to support the education mission of your institution? Do you require them to have a specific background?

2. Why do you think it is important for an institution to have educators?

3. How do you know your educators are doing their effectively?

4. How do educators fall within the museums mission and vision?

5. What do you think the future of museum education will look like?

6. Has your education program undergone any major change (either focus or structurally)?

7. What do you predict the future of museum education will look like?

8. Are there any science museums or centers you know of that are doing education ‘well’?

Appendix C: IRB Approval

UNIVERSITY OF ARKANSAS

To:	Bill McComas PEAH 310
From:	Douglas J Adams, Chair IRB Expedited Review
Date:	09/23/2020
Action:	**Expedited Approval**
Action Date:	09/18/2020
Protocol #:	2007274453
Study Title:	The Nature of Science Instruction in Museums: Case Studies of Exemplary Educational Practices in Programs, Personnel, Outreach and Organization
Expiration Date:	09/17/2021
Last Approval Date:	

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Courtney R. Erickson, Investigator