Integrating Art + STEM: An Exploratory Study of Three Science Centers

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Abstract

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Recently there has been increased attention from national organizations, policy makers, and educators on arts integration in educational practice. Arts integration appears in science center practice as well to achieve STEM learning. A wide range of efforts of arts integration with STEM subjects exists across science centers, however research in this area is nascent. This qualitative study examined the practices of three science centers integrating the arts in varying capacities to determine trends in the purpose, strategies, assessment, and challenges of arts integration at science centers. Findings suggest that the purpose of arts integration is to benefit science center visitors in multiple ways. These science centers collaborate with artists and external professionals to inform arts integration projects in different ways. The challenges of arts integration at these institutions include working with professionals from different backgrounds and making a case for funding. Finally, there seems to be no assessment strategies specific to measuring the success of arts integration at these sites. This research articulates recommendations to advance arts integration at science centers for both practitioners and researchers.

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CHAPTER 1: Introduction

Recently, there has been increased attention from national organizations, policy makers, and educators on arts integration as an educational practice, where arts integration is defined as learning through and with the arts in order to create relationships between the arts and other classroom skills and/or subjects (Burnaford et al., 2007). For instance, in 2013, the National Art Education Association (NAEA) announced its position in support of arts integration. The NAEA recognizes the importance of arts integration as a "philosophy, pedagogy, and methodology" that can enable a deeper understanding across disciplines, increase knowledge and skills in many content areas, enhance personal connection to learning, and motivate students (NAEA, 2013).

Similarly, it is thought by many researchers that when done effectively, arts integration can enable a deeper understanding across disciplines, motivate learners, and increase knowledge and skills in multiple content areas (Burnaford et al., 2007; Rabkin & Redmond, 2006). However, there is some debate concerning the extent of arts integration's impact on cognitive gains. For example, Burnaford et al. (2007) note that "arts integration researchers need to continue to test and critique methods for assessing the quality of teaching and impact on learning in arts integration curriculum…" (p. 76). In the literature, arts integration often appears in the context of formal learning environments (Burnaford et al. 2007), but there also appears to be a growing number of efforts integrating the arts with STEM subjects in science center practice ("Why?", n.d)

Two key examples illustrate the occurrence of arts integration in science centers. First, the Art of Science Learning (ASL) is a five yearlong research and development project investigating a range of arts-based learning approaches with STEM that is funded

by the National Science Foundation (NSF). ASL seeks to create a community amongst those interested in using arts-based approaches in informal science learning and dovetail interdisciplinary approaches with informal STEM learning (Luke & Butler, 2011). To meet project goals, ASL held conferences that brought together 425 artists, scientists, museum professionals, policymakers, educators, and leaders to develop communities of practice, explore how the arts connect to innovation and the 21st century economy, and share resources and ideas for best practices on using arts-based learning to strengthen STEM ("Reports & Outcomes," 2011). ASL will also develop arts-based STEM curriculum; three arts-based incubators for innovation located at different science museums across the country; research the impact of arts-based learning on the creativity skills, collaborative behaviors and innovation outputs of STEM learners; and develop a traveling art/science exhibition and public programs that use the project's activities and outcomes to advance STEM engagement ("Current Project: Phase 2," n.d.).

Another second example of an initiative designed to advance arts integration occurred in 2011 when the Exploratorium, San Francisco, CA hosted the NSF-funded Art as a Way of Knowing (McDougall, Bevan, & Semper, 2011). Art as a Way of Knowing (AWK) brought together 125 professionals working in art and science museums, education, contemporary art, and interdisciplinary research contexts. The conference proceedings were structured to facilitate a dialogue about the role of art in learning and science learning through presentations, discussions, and performances. The conclusions from the conference established primary areas of need for future work in arts integration: art as a way of knowing and art inquiry may be critical to engage the public in compelling ways; there is a need for better documentation of learning in interdisciplinary

contexts; more research is needed to better understand how learning in interdisciplinary contexts deepens understanding; how art/science collaborations have evolved since the 1960's; there is a need to cultivate interdisciplinary collaborations and synthesize knowledge.

While there may be interest in arts integration, as suggested by these two projects, the definition of the phenomenon, as well as its assessment methods and impacts, are not yet well understood (Burnaford, et al. 2007). In the literature, there appears to be many terms used to describe the connection between art and STEM, including interdisciplinary, STEAM, Arts-based Learning, Art Inquiry, and Art as a Way of Knowing. There also seems to be no common assessment indicators of successful arts integration experiences in informal science environments (Harrell, 2010; Smithsonian Office of Policy and Analysis, 2010).

While science centers are increasingly using arts integration to support STEM learning, there is little research showing how they are using it and measuring its impact. Therefore, the purpose of this research is to examine the ways in which science centers are integrating the arts with STEM learning practices. Through an exploratory study of three science centers, this research seeks to answer the following questions:

1. What is the purpose of arts integration at science centers?
2. What strategies do science centers use to integrate art into practice?
3. What are the challenges of arts integration at science centers?
4. How do science centers assess arts integration?

Exploring the intersection of the arts and STEM in science centers can serve to illustrate how, and why, some science centers integrate art into their practices. In

addition, although this research will not assess the impact of arts integration in science centers, this research will explore areas for future research to advance arts integration for both practitioners and researchers in informal science learning settings.

CHAPTER 2: Literature Review

Although there is a large body of literature on arts integration, research on this approach in science centers is emergent in nature. Therefore, the first section of this literature review will expand on what is known about arts integration in formal settings to serve as a foundation for this research. The second section will focus on efforts to support this area of practice to contextualize how art integration is being discussed and addressed. The final portion of this review will look at specific arts integration practices at science centers.

Arts Integration Research

The body of literature on arts integration suggests that this approach has continued to gain interest from many stakeholders. Research findings and assessment of arts integration appears largely from formal learning settings. Many professionals and organizations attest that there are benefits of arts integration practices for learners and communities, however the extent of arts integration's impact is not fully understood (Burnaford, et al, 2007).

A need to advance arts integration practice and research is identified within the education field (Burnaford, et al., 2007; Dwyer, 2011; Rabkin & Redmond, 2006). Burnaford et al. (2007) conducted a comprehensive literature review on what was written about arts integration between 1995-2007 to identify the trends that shape this field and what steps may be needed to understand what is unknown about this practice. This review synthesized three categories of arts integration definitions: learning in and through the arts; a curricular connections process; and collaborative engagement. Burnaford et, al (2007) concluded that the field of arts integration is in need of a research agenda to begin

to fully understand the implications of learning at the intersection of art with other subjects. Further investigation on which content skills/concepts, what strategies are the most effective for integration, and at which developmental level they are most appropriate for, was recommended. There was also particular attention paid to further research on the relationship between arts integration and transfer (the impact of the arts on cognition). Continuing to test the assessment strategies on teaching, methodologies and the impact of arts integration on learning is also essential. Finally, the dissemination of the results from assessment was described as important in supporting the continuation of arts integration.

There also appears to be attention on the need to advance arts integration at the federal level. The President's Committee on the Arts and Humanities (PCAH) conducted an in-depth review on the state of arts education in the United States (Dwyer, 2011). Over the course of 18 months, PCAH reviewed past federal efforts, reviewed pivotal and recent research findings, met with stakeholders and experts in numerous fields, and conducted site visits to exemplary arts programs across the country. From these data, PCAH published the report *Reinvesting in Arts Education: Winning America's Future through Creative Schools* that outlined five recommendations on the ways in which arts education in the United States can be advanced. One recommendation PCAH made is that the field of arts integration needs to be developed. During the research phase of this report, PCAH found that there was eagerness for the support and expansion of arts integration. According to PCAH, arts integration appears to make learning more appealing, helps students and teachers become more engaged, and school environments seem more creative. PCAH also stated in the report that statistics indicate that arts

integration contributes to raising test scores and student morale. Additionally, there are currently many models of arts integration in the United States, for instance the Chicago Arts Partnerships in Education (CAPE). The committee believes that in order to develop arts integration there needs to be communities of practice among arts integration programs to identify best practices on implementation, teacher training, curriculum organization, and common frameworks for the evaluation, and dissemination of arts integration research.

As PCAH discussed in their report, research has shown that arts integration garners positive results in enhancing student performance and raising test scores. There are examples of research findings from the report that PCAH thought to be exemplary models of arts integration, one of which is CAPE. CAPE is a partnership that was formed in response to address a need to create access to art in Chicago Public Schools (Burnaford, Aprill & Weiss, 2001). In the 1990's the CAPE network "was formulated as a model for making culture a true part of school culture by forging a clear connection between arts learning and the rest of the curriculum" and facilitating long-term relationships between teachers, art teachers, artists, and participating institutions (Burnaford, et al., p. xxxv). Over the course of six years, a framework to implement the arts into learning experiences was created by CAPE. It was found that the 19 elementary schools operating with the CAPE model showed consistently higher than average scores on reading and mathematics assessments over a six-year period when compared to that of other elementary schools in the district operating with non-arts integrated models (Dwyer, 2011).

Another arts integration model is North Carolina's network of A+ Schools. A+ Schools is a whole-school reform model that strives to create a learning environment that works for all learners (Burnaford et al., 2007). To enhance learning opportunities, A+ draws on Howard Gardener's theory of multiple intelligences, as well as other intelligences theories, and recent brain research. During the 4-year pilot of A+ Schools in North Carolina, seven Policy Reports evaluating the program were issued. During the last 3 years of the A+ pilot, it was found that students in A+ schools had academic achievement equal to other students statewide in mathematics and reading, which was considered compelling data because the program served schools with a large proportion of underserved and minority students (Burnaford et al., 2007). In addition to usual measures of student achievement and school success, A+ School Programs evaluators have found that the arts in education contributes to students' intellectual, social, and emotional growth. Data also indicated increased parental communication, community involvement, teacher collaboration, and a more positive learning environment.

Support for Arts Integration

Other national organizations appear to be providing forums and funding opportunities in support of arts integration. For instance in 2010, a joint meeting between NSF and the National Endowment of the Arts (NEA) was held (Harrell, 2010). This meeting brought together 55 leaders and stakeholders who straddle disciplinary lines for interactive discussion on the challenges and opportunities in bridging disciplines. The main goal of this meeting was to identify commonalities, foster collaborations between constituencies, and develop a set of areas of interest for connecting art with other subjects (Harrell, 2010). The conclusions from this meeting were: the fundamental concepts of the

arts and sciences must be mutually respected; disciplines should reinforce one another not detract from each other; there is a need for shared terminology and concepts; interdisciplinary areas do not have agreed upon metrics; an evaluation framework and best practices is necessary to assess impact interdisciplinary learning experiences; STEAM learning pedagogical outcomes need to be identified; and collaboration is important in advancing interdisciplinary research. Since then, NEA, NSF, and the National Endowment for the Humanities started a partnership to begin formally exploring how the organizations can work together at the intersections of art, science, and the humanities ("A Kind of Beauty," 2013).

In 2014, NEA announced their funding guidelines for programs in 2015. One funding area is Art, Science, and Technology. NEA made the following statement: "whether translating scientific data into visual, accessible forms or bringing methods of scientific inquiry to art-making, the worlds of arts, science, and technology are increasingly intersecting in exciting ways, an intersection that the NEA is interested in encouraging" (NEA, 2014)

There also seems to be a specific trend called STEAM, which is integrating the arts with STEM learning. STEAM is an acronym that stands for: Science, Technology, Engineering, Art, and Mathematics. The STEM to STEAM initiative, which is attributed to the advocacy efforts of the Rhode Island School of Design, is intended to add art and design to the national agenda of STEM education and research in America ("About STEM to STEAM," n.d.). RISD's goal of STEM to STEAM is "to foster the true innovation that comes with combining the mind of a scientist or technologist with that of an artist or designer" ("About STEM to STEAM," n.d.).

It seems that there are examples of how STEAM is being supported. For example, according to STEAM Connect, a forum dedicated to bridging the art, science, and education community, STEAM sparks “the interplay between left-brain convergent thinking and right-brain divergent thinking. In a rapidly changing world, we all must become well-rounded global citizens who have the imagination and skills to conquer new challenges. STEAM is the catalyst for this.” (“What is STE[+a]M?,” n.d.).

In 2010, NSF funded "Bridging STEM to STE(A)M: Developing New Frameworks for ART/SCIENCE Pedagogy," which was hosted by RISD. The workshop aimed to develop an educational agenda on merging the arts and design with STEM. Experts in science, technology, educational research and the arts met to discuss how to bridge STEM with creative processes. The goals of this initiative were to: “develop strategies for enhancing STEM education through the integration of art and design thinking (STEM + ART = STE(A)M); invent and share techniques that take advantage of simple, freely available IT systems and applications to support enhanced observation, analysis and understanding of pictorial and numerical data; build new connections between art and design disciplines and scientific fields to advance understanding of complex systems” (NSF, 2010).

In February of 2013, Congresswoman Suzanne Bonamici and Congressman Aaron Schock announced the formation of the Congressional STEAM Caucus (“Congressional STEAM Caucus,” 2013). The Congressional STEM Caucus advocates for policy changes to encourage educators implement arts integration practices. The STEAM Caucus’ goal is “to encourage the creativity needed to drive our innovation economy forward” (“Congressional STEAM Caucus,” 2013). The first briefing was

sponsored by the RISD, during which time RISD President John Maeda made the following statement: “I believe art and design are poised to transform our economy in the 21st century like science and technology did in the last century.” Maeda went on to say:

> Adding art and design to STEM to create STEAM will keep America competitive. As a lifelong STEM student – I spent many years at MIT before coming to RISD – I’ve seen firsthand the progress that STEM education can produce. But I’ve also witnessed STEM’s limits. Innovation depends on the problem solving, risk-taking and creativity that are natural to the way artists and designers think. Art and science – once inextricably linked – are better together than apart. (“Congressional STEAM Caucus,” 2013).

Science Center Practice and Arts Integration

As support for the advancement of arts integration has grown in other sectors, arts integration appears to be more prevalent in the museum field as well. In particular, a growing number of science centers have integrated the arts into informal science education exhibits and programs to promote increased engagement with the sciences (“Why?,” n.d.). There appears to be little documentation on arts integration in science centers. However, there are some examples in the literature that denote shifts in the museum field concerning arts integration.

There is a wide range of ways in which the arts are combined with STEM. For instance, some science museums have incorporated art into every aspect of their practice. An example is the Exploratorium. This museum has integrated the arts since the organization’s inception (“Arts at the Exploratorium”, n.d.). The Exploratorium’s pedagogy emphasizes that the arts are fundamental to discovery and understanding the world. Founding director Frank Oppenheimer believed that there were many

commonalities between the arts and the sciences. According to Oppenheimer science and art,

> Both begin with noticing and recording patterns- spatial patterns, patterns in time, patterns of process, and behavior. The both elaborate, reformulate, and ultimately link together patterns, in nature and in meaning, which initially appeared as unrelated. Both art and science are involved with order-disorder transitions and the creation of tension and the relief of tension. Both endeavors are deeply rooted in culture and heritage; both expand our awareness and sensitivity to what is happening in nature and in ourselves. (Exploratorium, n.d.)

Peter Richards, Senior Artist Emeritus at the Exploratorium is an advocate for the presence of artists in science museums (2002). Richards worked with Oppenheimer to create arts programming and the Artist-in-Residence program at the Exploratorium in the 1970's. Richards believes that artists make learning environments more diverse; working with artists creates more opportunities for museums to connect with their communities; art can make people excited to learn about the world and science phenomena; and the different perspectives that artists bring to a science museum informs content and can positively impact future art work by an artist (Richards, 2002).

Another example of arts integration in museum practice is the Leonardo in Salt Lake City, Utah. The Leonardo explores the ways in which art, science, technology, and creativity intersect through their interactive exhibits and programming. (The Leonardo, n.d.). The Leonardo's educational philosophy draws on the Leonardo Da Vinci's theories, the STEAM movement, and 21st Century Learning:

> Drawing on the thinking of Leonardo da Vinci, who saw all knowledge as related and all the world's disciplines as one whole, The Leonardo's educational programming integrates all fields of learning through hands-on, inquiry-based experiences to sharpen students' abilities to think creatively, critically analyze their own ideas, and solve real problems. These first-hand learning

> experiences promote divergent thinking as students explore subjects through a wide array of lenses, providing the foundation to solve a lifetime of unusual constructs. Through school visits, educator training, ongoing programming, and on-site exhibits, the Leonardo invites students to take part in extensive inquiry and investigation. By integrating cutting-edge innovation with creative thinking in formal and informal education and fusing science, technology, engineering, math, and art with core curriculum, The Leonardo promotes the 21st century skills critical to building tomorrow's leaders. ("The Leonardo's Education Philosophy," n.d.)

Another example of connecting the arts with the sciences in a museum setting is at Explora in Albuquerque, New Mexico. Explora's mission is "creating opportunities for inspirational discovery and the joy of lifelong learning through interactive experiences in science, technology and art." (Explora, n.d.) Examples of integrating art at Explora include their exhibition's Light Shadow Color, and Math Moves! ("What to do- The Exhibits," n.d.). Both of these exhibits allow for visitors to engage with STEM content, (i.e. optics and math) through drawing, movement, and exploration with color.

While there are science centers integrating art into a wide range of efforts, research on arts integration in the museum field is growing. In 2009, the Smithsonian's Office of Policy and Analysis (OP&A) conducted a study on collaboration and interdisciplinary work at the Smithsonian entitled *Interplay of Perspectives: History, Art & Culture + Science Interdisciplinary Crossover and Collaboration.* OP&A defined interdisciplinary as "an activity involving two or more academic, scientific or artistic disciplines" (OP&A, 2010, p. 8). Interdisciplinary collaboration can take many forms but was defined by OP&A in three ways: side-by-side, when two or more subjects exist in parallel; overlap, when disciplines pose common questions themes that exist between the

two; and synthesis, when two disciplines join together completely to generate new questions and themes (OP&A, 2010).

OP&A examined research, programs, and projects that intersect art, science, cultural studies, and history by looking primarily at the work being done at the Smithsonian. The report specifically looked the benefits and challenges of integrating disciplines. Data collection for this study included 14 interviews with Smithsonian staff members and 11 interviews with staff from external organizations involved in interdisciplinary work; artist studio and lab visits; researcher attendance to artist talks, lectures, exhibits, and conference proceedings; a literature review on interdisciplinary research; and a selective review of relevant web material. The data revealed that staff from the Smithsonian and other cultural institutions perceived that the benefits of interdisciplinary collaboration and practice fell into three themes: the knowledge and methods of one discipline can spark creativity and discovery in another; collaboration between disciplines can provide social commentary and activism; the arts can communicate science to a wider audience. The report also identified themes in strategies to bring disparate disciplines together such as having artists and art spaces in science organization; interdisciplinary laboratories and studios; grant programs; advocacy; think tanks and conferences; teacher training; and curriculum reform.

At its conclusion, OP&A felt that this report was a jumping off point and that there were opportunities for interdisciplinary practices to continue to grow. First, OP&A believed that defining successful interdisciplinary collaboration and evaluation practice is important for museums and other cultural institutions that have interdisciplinary initiatives. OP&A found it is necessary to continue to research and build evaluation into

these efforts to understand "what [interdisciplinary experiences] mean for people who walk through the door" (OP&A, 2010, p. 8). The report also gleaned ideas of how to address the divide between disciplines from the data including: looking to visionary people; do justice to both disciplines; using boundary spanners; finding ways to overcome language barriers; and ensuring structure and incentive for interdisciplinary collaborations (OP&A, 2010).

There has been discussion among other museum professionals addressing the need for common impact indicators to determine the success of integrating disciplines. For example, panelists at the Visitor Studies Association (VSA) 2012 conference who participated in the "Art + Science= New Engaged Communities" session exchanged their perspectives on the importance of the intersection between art and science. VSA's conference catalogue highlighted that art and science share many similar qualities but there are no common impact indicators to assess the impact of art and science impact ("Knowing our past, shaping our future. What's next for visitor studies?," 2012).

It has been discussed in the literature that there is a need to build evaluation efforts into projects that connect the arts and STEM. However, there seem to be some examples of evaluation in interdisciplinary experiences. For example, in 2010 Randi Korn & Associates (RK&A) conducted a summative evaluation of the Science & Art Exhibition, a traveling exhibition created by the Science Museum of Minnesota. One of the evaluation's objectives was to explore the impact and effectiveness of the exhibit in helping visitors make connections between art and science and the messages that visitors took away from this experience. RK&A observed 119 and interviewed 50 visitors at the Mid-America Science Museum in Hot Springs, Arkansas. Visitor engagement in the

exhibit was high with many visitors using interactives (98%) and many visitors looking at the artwork in the exhibition (80%). Less than one-third of visitors said they made connections between the two subjects, and less than one third of visitors' responses indicated messages related to art and science. When visitors were asked to describe their thoughts about art and science, about one third of visitors gave responses that ranged from "creativity to responses about how science is integrated into everyday life" (RK&A, 2010, p. 5) RK&A concluded that despite strong visitor engagement with the exhibition, many did not grasp the exhibition's main message: there are connections between art and science. RK&A recommended that steps needed to be taken in order to address overcoming the challenges of conceptual orientation within the exhibition.

Summary

The body of literature on arts integration indicates that there are many benefits to this practice and continued interest. However, there is little that is known about what the impacts are of arts integration in informal science learning settings despite growing interest in this practice in science centers. The literature points to further opportunities to address the development of arts integration initiatives within informal learning settings, as well as continued discussion around the definitions, strategies, implementation, and assessment of such initiatives.

CHAPTER 3: Methods

The following section will describe the methods used to conduct this research. The first section will restate the questions guiding this study. The second will discuss the protocol used to identify the sites informing this research and study participants. The third will describe the instruments used for this research. This chapter will conclude with information about the data analysis of this study and its limitations.

Research Purpose and Questions

The purpose of this study is to examine the ways in which science centers are integrating the arts into STEM learning practices. This research seeks to answer the following research questions:

1. What is the purpose of arts integration at science centers?
2. What strategies do science centers use to integrate art?
3. What are the challenges of arts integration at science centers?
4. How do science centers assess arts integration?

Methods

This is an exploratory study with qualitative data collected from three science centers. A case study approach (Yin, 2009) was used to understand the phenomenon of arts integration in the science center context, as it exists at these three sites and what commonalities exist between them.

Sample

The sites informing this research all have current arts integration activities, programs or exhibits available to museum visitors. To identify the science centers that served as case studies for this research a best-case scenario method was used. Through

online searches, and recommendations from museums professionals, three sites were identified as ones that were well known for their arts integration efforts. The rationale for this sampling strategy was that it was the best way to conduct this research given the time constraints and logistics during the time frame this research was executed.

Once sites were identified, the information about staff available on public sources (i.e. science center websites) and convenience sampling was used to identify potential participants. Interview participants had to meet the following criteria: they were directly involved with the research, development, implementation, and/or evaluation with a project that integrated the arts at each science center. The three sites are:

- The Exploratorium, San Francisco, CA
- New York Hall of Science (NYSCI), Corona, NY
- Oregon Museum of Science and Industry (OMSI) in Portland, OR

Instrument

The instrument used for data collection was interviews with science center staff. Participants were given the option to participate in the interview either over the phone or over Skype. Interview questions were designed to seek answers to the following concepts in the research questions: purpose, strategies, challenges, and assessment of arts integration at science centers (interview guide can be found in appendix b). Two staff participants from the Exploratorium were interviewed, one whose role is to direct arts strategy at Exploratorium within the Center for Art and Inquiry and one who is an artist on staff who works with interdisciplinary teams to develop exhibits. Three participants from NYSCI with the following roles were interviewed: two public programs staff who are responsible for bringing in programs and temporary exhibits that connect the arts and

sciences and an exhibit developer/project manager. Two staff members from OMSI were interviewed. One participant is from the exhibits department and another from the education department.

Participants were asked to participate via email and given a consent document regarding the nature of the study and asking their willingness to be interviewed. The consent form can be found in appendix a. Participants confirmed their willingness to be interviewed by email. The length of interviews ranged from 35-85 minutes. Content from case study websites and documents volunteered by participants were also informally analyzed to contextualize the interview data.

Data Analysis

Results from the data were drawn from emergent themes as they related to the research questions. The interviews were recorded and transcribed. Each interview was read individually for emergent themes and then responses were compiled by case. Themes in data were organized as they related to each research question and a cross analysis between case study sites was conducted to determine common themes on arts integration between these science centers.

Limitations

This research is not without limitations and this section will outline what those limitations are. First, this is an exploratory study. The data collected for this study represent three cases, and therefore cannot be generalized and applied across all science centers. This research also does not represent arts integration practices at other types of organizations. Another limitation of this research is that the support for arts integration varies between science center sites. For example, the Exploratorium has programs and

staff dedicated to advancing arts strategies in the organization's practice. Whereas at NYSCI and OMSI, there are neither staff members nor departments appointed to solely to facilitate arts practices. Also, every institution is different. The data collected could have varied depending on the level, and role of staff members at each site.

Other limitations occurred during the data collection process. Only one interview of the seven was conducted via Skype. Another had to be conducted over the course of two days due to a loss of phone service. One interview was completed by email because the participant suddenly had to return to their responsibilities and was unavailable to speak again by phone. And finally, time and availability of staff are also limitations to note.

CHAPTER 4: Results

Introduction

This chapter describes the results from this research. The first section provides an overview of the sites informing this research including basic institutional information, mission and vision, and key arts integration efforts. Each site incorporates varying degrees of arts integration into their current practice. Exploratorium has intentionally integrated art in all museum initiatives since the museum opened. NYSCI has long standing history of arts integration and frequently utilizes this strategy. OMSI has used arts integration in fewer capacities but currently has participatory activities spaces that connect the arts with STEM. The remainder of the chapter illustrates results, which are organized by research question, and key themes that emerged in the data.

Science Center Site Descriptions

The Exploratorium

The Exploratorium in San Francisco, CA is a museum of "science, art and human perception" ("About," n.d.). Dr. Frank Oppenheimer founded the Exploratorium in 1969. Exploratorium's mission is "to create a culture of learning through innovative environments, programs, and tools that help people nurture their curiosity about the world around them" ("Why the Exploratorium?," n.d.). Art has played a fundamental role in the Exploratorium's initiatives since the museum's inception. According to a study participant, "there was a very strong intention to combine the arts and sciences from the very beginning" and arts integration at Exploratorium is implemented strategically.

Currently, there are many programs and exhibits that connect art with the sciences at Exploratorium ("Arts at the Exploratorium," n.d.). There have many efforts throughout

the Exploratorium's history that denote institutional dedication to include the arts with museum practice. For example, when the Exploratorium opened in 1969, the museum hosted the exhibition Cybernetic Serendipity, an exhibition initially shown at the Institute for Contemporary Art in London. According to Exploratorium staff, Cybernetic Serendipity is thought to be the seminal art, science, and technology integrated exhibition. In 1974 the Exploratorium began the Artist-in-Residence Program ("Artist-in-Residence Program," n.d.). The museum works with artists interested in creating interdisciplinary works and developing new methods. One study participant said that Exploratorium engages "artists in every facet…to inspire curiosity and to further an interdisciplinary approach to seeing and understanding the world." Artist-in-Residence projects have been developed to resemble a wide range of artistic practices such as immersive installations, performances, theater productions, and online projects. The program's objectives is to allow artists to embed themselves within the institutional culture of the Exploratorium, provides opportunities for public engagement, and affords artists access to museum resources.

As discussed in chapter one, in 2011 the Exploratorium hosted the NSF-funded conference called Art as a Way of Knowing (AWK). The conference proceedings were structured to facilitate a dialogue about the role of art in learning, and in particular science learning (McDougall, Bevan, & Semper, 2011). After the conclusion of AWK, the Exploratorium has continued to advance research on how the work and role of artists shape the work of staff and visitor experiences. This decision led to the establishment of the Center for Art and Inquiry (CAI), a division of the museum that serves as a research and development laboratory for arts at the museum ("Center for Art & Inquiry," n.d.).

CAI directs the Exploratorium's arts strategy and seeks to expand the museum's focus on art as a medium for inquiry and discovery. CAI initiates projects to advance work of interdisciplinary learning. Additionally, CAI works with directors from across the museum and an advisory council to inform their approach ("Center for Art & Inquiry," n.d.).

New York Hall of Science

NYSCI is located in New York City and was established in 1964. NYSCI's mission is "to convey the excitement and understanding of science and technology to children, families, teachers and others by galvanizing their curiosity and offering them creative, participatory ways to learn" ("About," n.d). NYSCI has frequently engaged with the arts for a significant portion of its history but the arts do not inform all of the museum's projects. At NYSCI, the arts have a "deceptively simple role: to help visitors learn" (NYSCI, 2006, pg.1). Dr. Alan Friedman's leadership as NYSCI's director from 1984-2006 has been attributed to the arts having a significant role at the museum. Friedman (1997) believed that the arts can create a desire to learn and that artistic outputs, such as painting and sculpture, can offer another way to explain science content.

Art at NYSCI is implemented in many ways. The museum has an art collection, site-specific art installations, exhibits, and public programs with themes relevant to STEM content (NYSCI, 2006). Interview participants explained that art was connected to STEM at NYSCI primarily through temporary exhibitions and art installation, as well as public programming designed around STEM content, which tends to provide project-based activities to convey topics. Artists are often invited to collaborate with museum

staff on exhibits and programs at NYSCI. For instance in 2012, 10 artists were invited to create installations for the exhibition ReGeneration.

NYSCI has shown many art exhibitions curated by the Art & Science Collaborations, INC (ASCI). ASCI's mission is "to raise public awareness about artists and scientists using science and technology to explore new forms of creative expression, and to increase communication and collaborations between these fields." ("About Overview," n.d.) According to ASCI's "12 Year Report," the organization appears to have had a working relationship with NYSCI since 1992 ("12 years @ Art & Science Collaborative," 2000)

NYSCI has also devoted resources to engage visitors with design concepts. Spaces have been created at NSYCI for visitors to participate in design challenges. For example, a Maker Space is located at NYSCI. Maker Space at NYSCI is: "a learning environment where children, teens, adults and families can tinker, design, and create together" ("Makerspace at NYSCI," n.d.). In June of 2014, NYSCI will open a permanent exhibit called Design Lab. Design Lab "will allow visitors to engage in activities, experiments and challenges that provide a deeper understanding of engineering and the design process" ("Design Lab," n.d.). It is the goal of NYSCI that the exhibit will encourage visitors to be inspired by the resources provided to them in the lab and find new ways in which to use them.

Oregon Museum of Science and Industry

OMSI in Portland, Oregon has served visitors and Northwest residents since 1944. OMSI's mission is to "inspire curiosity through engaging science learning experiences, foster experimentation and the exchange of ideas, and stimulate informed

action" ("About OMSI," n.d.). OMSI's vision statement is "OMSI, collaborating with partners, will ignite an education transformation at the intersection of science, technology and design, and weave a thriving innovation district into the fabric of Portland, that spreads opportunities across the Northwest" ("About OMSI," n.d.).

OMSI has used arts integration programs and exhibits minimally through out its history as an organization. According to an interviewee, art is not a part of a specific initiative at OMSI and "there has not been a lot of arts integration. There have been some examples in individual activities that educators have created to go along with a concept…but that is informal and happens on the floor…My observation, my experience, has been that it is a little bit more of an ad hoc basis." However, another interviewee specified the Makerspace and Physics Lab as "two key STEAM things we do around the museum." This same participant also discussed that despite the arts not being tied to any specific initiative "I think that [art] has been a part of OMSI's culture for a long time. When we redefine using art, it has really been about learning science process skills…I would not call it something new to OMSI. I would call it a rebranding of how we are describing ourselves."

An example of OMSI using art to convey STEM content is the traveling exhibition Design Zone. Design Zone is an exhibition that creates non-traditional, experiential learning experiences with math. The exhibit was created as a means to "promote innovation and build math literacy" which OMSI deems as essential for the 21st century workforce ("Design Zone," n.d.). To present math in a compelling way, the exhibit draws on three themes: art, music, and action. Art belongs in Design Zone because designers of all kinds use mathematics with visual creativity. The concepts that

connect art with math in the exhibit include: visual patterns, scale and proportional reasoning ("Design Zone," n.d.).

Results

Research Question 1: Purpose of Arts Integration

Benefiting Visitors

Data from the sites indicate that the purpose of arts integration is to benefit visitors. Sites also discussed these benefits as having impactful results. However, these science centers all discussed how the purpose of arts integration is to benefit visitors, but sites described this benefit in different, sometimes overlapping ways.

Entry point for STEM content. Participants from OMSI and NYSCI discussed how art could afford visitors access to STEM content. OMSI emphasized how the arts can be an entry point for engagement with STEM content. For instance, at OMSI "a lot of times when we are looking at exhibit development, we are looking for multiple entry points so that more people can be engaged with what we are doing and the concepts, and the learning that's possible and the experiences that we create." Later in the interview, the same participant stated: "In the interest of providing multiple entry points for people with different lived experiences and interest, having the arts as part of what we do makes a lot of sense." NYSCI commented that arts integration allows for "different ways to approach concepts… and hands-on projects allow different points of entry" for visitors.

Connection between content areas. Sites discussed that when combined, the different perspectives from the arts and sciences illustrate how subjects are interconnected. At OMSI, one participant discussed how presenting STEM content with the arts could demonstrate how subjects are interrelated:

> One of the key benefits that we have identified is that [STEAM] creates more interconnection between content areas. For instance, physics is not just physics, chemistry is not just chemistry. It's really about the design process and about how those different content areas add up to a more holistic understanding of science. STEAM is a chance for us to talk about the interconnection of science content.

A participant from NYSCI also discussed the connections between different content areas:

> There are a lot of natural connections between art/science/technology that are interesting…that are beneficial to explore. I think often complex ideas and concepts are more easily understood when they are in the context of a project that, or an exhibit that, sometimes puts those ideas into sort of an everyday or accessible context. And I think that for us just seeing the world in a much more holistic way is important because these [art and science] are not naturally that separate. There's science in art, there's art in science. There's creativity in all of those things and I think that seeing it that way in an important thing to share and extend and have dialogue around with our audiences.

Deepens learning. Sites also discussed how arts integration could deepen the visitor learning experience. For instance, OMSI discussed how the arts could allow visitors to reach greater levels of science engagement. For example, art is "a way for people to see themselves as moving from being curious to taking action, or getting to another level of science learning phenomena." NYSCI and Exploratorium discussed that arts integration enables different ways for visitors to make sense of the world through inquiry and hopes that visitors see there are many to interpret to world. The Exploratorium wants the "world to understand that there are different ways to approach inquiry… So we are trying to show [visitors] that they are all ways to approach the world around them." And that there are many "valid ways of understanding the world around you." Similarly at NYSCI, the following comment was made during an interview: "there

is validity in different interpretations. I think that encouraging people to interpret things on their own would help them understand science better, in addition to art."

Exploratorium felt that art supports the visitor's inquiry process and discovery about scientific phenomena and the world around them. At the Exploratorium, one interviewee stated, "Overall, our philosophy is to further engagement, to inspire a questioning, curious populace. And the arts are in that mix because the arts as a process alter people's perceptions and ways of thinking."

Empower visitors. The word empowerment came up during data collection with NYSCI and Exploratorium. For example, a participant from NYSCI said that arts integration at their organization is not a "not a didactic, heavy-handed approach." The interviewee went onto say that the use of art enhances discovery for visitors: "you discover for yourself by being invited to do something because more of the [art] exhibits are participatory. You are empowered to be able to say that you could understand the concept. And I think that's what visitors get out of it."

An Exploratorium participant also expressed that "we want to empower people. We want them to be participants in their own discovery. We want the public to participate and discover in a proactive way their own creative capabilities, the power of their own question, the delight that they might have in making a discovery." The participant went on to say that in addition to the arts promoting a sense of empowerment for visitors, the arts can lead to an engaged populace and alleviate societal issues:

> We see ourselves as wanting to inspire creativity, imagination and social change. The arts are key to that. People being aware of what is around them, engaging with communities and being proactive inquirers, learners and advocates for the things they are passionate about. We were founded in the wake of World War II and the dropping of the Atom Bomb. I think that there was a sort of

> democratic idea behind Oppenheimer's vision. In order to avoid catastrophes like that in the future you need this very engaged populace. So we have different challenges today but they are just as serious. The answer is a public that is well educated, curious, and empowered to be question askers.

Intended Audience

Audiences for arts integration experiences are not thought of as different from other visitor groups. It seems as if some efforts are tailored to certain audiences, but the audience for arts integration experiences does not seem to be thought of as its own category of visitors.

In most cases, interview participants discussed the audience for arts integration experiences as being the same as the intended audience of the rest institutional efforts. The Exploratorium strives to engage a very broad audience: "6 to 96 years- everyone." There is something for everyone at Exploratorium. For instance, when asked who benefits from arts integration one interviewee said: "the culture at large you might say." Another interviewee said, "the public."

At OMSI the overall institutional target audience is 6-10 year olds. One participant said that in terms of arts integration: "Almost anyone can benefit from arts integration." Later in the interview, the same participant said, "I don't think there is a single audience."

NYSCI participants stated the museum has an overall main target audience of 4-12 year olds. When asked about who benefits from arts integration, participants said that anyone can, but for the most part children do. One interviewee commented,

> Everyone [benefits from arts integration]. I mean I wouldn't necessarily break it down into age groups. I think everybody gets something different out of it. I think probably kids more naturally because they haven't set up those barriers for themselves yet. And

> it is sort of all about how you teach people about the connections between things. And I think that likewise adult audiences are a really interesting topic to explore intersections and connectedness with those groups as well because they the wherewithal and the maturity to pull from the experiences to contribute to that dialogue as well.

However, at NYSCI there has been some effort to attract a different audience with public programs and the exhibition ReGeneration. This participant also discussed how the museum has been reaching out to a different audience through these initiatives: "We target different audiences for our different workshops. With these activities we are also reaching out to a slightly older audience." Another interviewee discussed how the museum was hoping to broaden their audience by having an art exhibition: "I think the perception here is that it was going to be an audience older than our typical audience. Our hope was to bring in adults."

Research Question 2: Strategies of Arts Integration

Each case study site discussed a range of strategies when developing projects using the arts. However, two key themes emerged across case study sites. First, case study sites explained many collaborative strategies that inform the development and implementation for Arts Integration projects. Second, sites designated particular spaces for visitors for visitors to create their own art and/or design projects.

Collaboration

During the interviews with case study sites, external collaboration appeared to be key to implementing arts integration efforts. Collaborative efforts for these sites were multi-faceted. First, these science centers collaborate with artists to varying degrees and do so for differing reasons. Science center staff members also seek insights from many external professionals such as architects, engineers, and the DIY communities. There was

also commentary on fostering community relationships through project planning. Each of these areas of collaboration is outlined below.

Artist Collaboration. The extent to which artists were invited to collaborate varied across the case studies, and the particular role that the artist played was different at each case study site as well. At the Exploratorium, artists and staff have work together to create integrated experiences since the museum opened. Artists, both on staff and in residence at the Exploratorium develop and design museum experiences through exhibits, public programs, and public art. One interview participant expressed that the Exploratorium "strategically" invites artists to work with the museum. For example, the Exploratorium invites resident artists with many specialties in mediums and at various levels in their careers "who are drawn to collaboration, interested in interdisciplinary dialogue, and open to developing new working methods" ("Artist in Residence Program," n.d.). When an artist is in residence at the Exploratorium, there is typically an exploratory and project development phase over the course of two years ("Artist in Residence Program," n.d.). According to an interviewee, Exploratorium is "interested in how the artist inquired about nature or concepts and built that inquiry into the object that then other people use."

The interviewee also noted that their institution views the exchange between artists and staff as a synergetic relationship. Artists in residence are able to use the resources of the institution, such as the provision of space and the materials to carry out their vision, and Exploratorium's staff has opportunities to learn new processes and reinvigorate their practice. On an institutional level, the museum believes,

> Artists get ideas that are unique and think of approaches that are not in the culture of normal exhibit development. So they influence

> the exhibit developers to try new things in new and compelling ways because they bring a background that none of us have here. It's a two way street.

The participants from the Exploratorium both have a background as an artist. One participant's role is specifically to be an artist on staff that develops exhibitions and installations. During an interview, the interviewee stated:

> I came to work at the Exploratorium because I was a young artist trying to have a job that also fed my creativity. At the Exploratorium I could…I could learn about science. I could work with artists in residence. I could contribute my own artful ideas and expand my thinking…Here I learn so much. It's really broadened my scope of what I think is possible.

Like the Exploratorium, NYSCI also has a long history of working with artists. Contribution from artists occurs frequently at NYSCI but they are commissioned to specific projects such as workshops, panels, and special exhibitions. At NYSCI, the role an artist has is associated with improving STEM learning by conveying complex STEM topics such as climate change and sustainability. An interviewee said "often times we've looked to artists of the creative communities to sometimes bring in more complex issues into a project that breaks down those topics for our public and produce hands-on projects that kind of drives those ideas home." Another interviewee stated that at NYSCI many of the exhibits "were designed and developed by artists with scientists at the museum to create an exhibit that was aesthetically pleasing, that has science content, so that [visitors] were drawn to it because of the appeal and wanted to know more."

Interviewees from OMSI stated that the arts are integrated in the museum's practices in more focused capacities such as temporary/traveling exhibits, educator facilitated activities on the museum floor, and the museum's Makerspace. For the projects done at OMSI, there has been little collaboration with artists. In one special case,

artists were consulted during the conceptual phase of exhibition planning to ensure OMSI authentically represented how the creative processes are related to STEM subjects. For instance, according to a participant, consultation with artists was

> More in that early phase of research rather than through the design and building per say. It was more [of a] jumping off point, talking to people, delving into what they do. What aspects of that might be things that might be the basis for exhibit experiences. So it was more in the early conceptual development. We were visiting studios and talking to people and that kind of thing. Later of course we work with animators and software developers. But primarily I would say in conceptual development to ground our thinking in creative work.

In terms of OMSI's educational activities using the arts, artists have not been involved. An interviewee said, "at this point we really do not [work with artists]. Although it is certainly an area at OMSI that we have identified as something we want to do in the future." While artists are not involved, the interviewee thought the notion might be beneficial for future initiatives.

Broader collaborative efforts to inform practice. All three case study sites regularly engage in collaborative efforts with external professionals. External professionals in STEM areas often inform or assist with project completion at these sites. Interviewees also discussed collaboration with museum professionals as an important part of project implementation.

Examples of external professionals ranged from positions in the art world to those in the STEM sectors. One interviewee from the Exploratorium discussed the collaborative efforts of a project that included engineers, advising curators, and marine salvage experts to build an exterior art installation. As they explained the dynamics of project development, they expressed: "I have to say there is great people power behind

it…There was that kind of richness in terms of ideas and exchange." Another Exploratorium interviewee stated that museum is "interested in imaginative people that help us unravel the mysteries of the world."

Participants at NYSCI also discussed working with advising curators to coordinate what artists should be invited to work with the museum. One example was during the curation of the exhibition ReGeneration. NYSCI worked with advising curators who sent out a call to artists and selected 10 that best fit the exhibition's theme. Another NYSCI participant discussed how architects have periodically been involved with installations on site.

At OMSI, external professionals are also consulted. In one instance, to inform a specific exhibit that combined math with art, exhibit developers "wanted to create authentic experiences with math and visual art, math and music, and math and engineering." So staff started going out in the community to meet with professionals such as bike designers, architects, and music producers to find out what math played in their careers.

Collaboration between museums. Across all of the case studies, there was also an emphasis in looking to professionals in the museum field to inform projects. By working with colleagues in the museum field, study participants discussed how their practices are enhanced. This inter-museum exchange seemed to be of importance to all case study participants during these interviews.

One interviewee at NYSCI said that to inform projects NYSCI staff "talk to other museum people. We are part of a community of science centers. Learning about best practices from colleagues is a big deal." Another example from a participant at the

Exploratorium stated: “Being part of the science museum world, we have colleagues that inform us about their impressions on how they think we are doing. Or we see there are many science museums that are incorporating artists into the development process. So it’s a much wider, broader community in which we exchange ideas.” Additionally, an exhibits staff member at OMSI also discussed the importance of looking to the museum field. As this participant discussed the external resources informing their approaches they stated: “Going to museums…we did a lot of road trips that were great. Those were really inspiring…we went to museums in the bay area. Learned from other exhibits…we were sponges looking for experiences that informed our work.”

Interestingly, both OMSI and NYSCI interviewees referred to the Exploratorium’s practice at various points in the interviews and how that had impacted their own decisions in project development. For instance, an OMSI staff stated, “we went to the Exploratorium to work with colleagues there who were working on [a similar project] and there was a lot of really good conversation there that informed our work.” The same participant at OMSI discussed how the Exploratorium’s “Fostering Active Prolonged Engagement” research was helpful in developing their projects (Humphrey & Gutwill, 2005). A participant at NYSCI also discussed connections with the Exploratorium as impacting practice: “I think that a lot of museums, certainly following the Exploratorium mode, always had artists who were involved in science.”

Community. The case study sites discussed the significance of community ties informing arts integration initiatives. Understanding the community prompted the staff at these museums to see how the resources of each institution can be leveraged and in what

ways these organizations can address community needs. During an interview with an Exploratorium participant, the following statement was made:

> I like to think of our center as both looking inward to the museum and understanding its context and its talents and resources. And also looking externally at what is rich in the field of the arts. And what is rich in our arena that overlaps art, science, and education. What great thinkers can we pull in to work with us like as writers, advisors? What visionary leaders in the community would support projects like this? I feel like our job is looking externally and internally simultaneously.

One interviewee from NYSCI explained how community demographics and information about the museum's community helped shape an exhibition: "I think it was more the data set… the realities of Queens itself, and looking at Queens, which is an ultra diverse community." A participant from OMSI said,

> Being a good partner with other cultural institutions is important to us. Working closely with them to understand what the community needs are and understanding where gaps are in the community. Whether its art, science, engineering, working closely with partners to understand how OMSI can be of service to the community and what gaps we can help fill is a priority for the museum.

Designation of Space Another theme that appeared when discussing arts integration strategies was the designation of spaces at these museums for arts-related activities. The concepts embedded into these spaces were multi-faceted. Across the three sites, there was discussion about design, experimentation, and allowing visitors to have creative autonomy. These spaces are areas in these science centers in which visitors have the opportunity to be experimental and have autonomy in creating a project during their visit while there is mentorship from museum facilitators.

Makerspaces. While the researcher did not discuss the Maker Movement, the topic came up frequently during these interviews. The Maker Movement is a movement

emphasizing the importance of individual learning design, tech, and engineering skills and applying them in creative ways (IMLS, 2012). In museums, the Maker Movement is seen primarily through Makerspaces which are "hands-on, mentor-led learning environments to make and remake the physical and digital worlds" (IMLS, 2012, p.1). These science centers have all participated in the Maker Movement in some way.

OMSI and NYSCI have Makerspaces on-site. Exploratorium has a similar space called The Tinkering Studio, which will be discussed in the following section. Additionally, sites have recently participated in Maker Faires according to content online. The level of Maker involvement appears to be higher at OMSI and NYSCI. At both NYSCI and OMSI art, design, and DIY were discussed together by participants.

OMSI and NYSCI participants discussed how Maker is a method used by the museum to connect the arts and STEM. Makerspaces at these two sites allow for visitors to tackle design challenges. The intent of these spaces is to allow visitors to find creative, innovative approaches "to make." According to a staff member at OMSI, Makerspace is an intentional way in which the museum incorporates the art into their practice. The same staff member went on to say that "art is about design also. It's about the ability to try many different things. One message that is really important is the belief that by participating in an art and science activity, you are also willing to try many different ideas and explore…" This perspective indicates how art and design support sustaining visitor interest in STEM at OMSI. Interestingly, when discussing trends in arts integration, another OMSI participant said:

> New York Hall of Science has been working on a series of spaces, Makerspace and design. Where the focus is on design and creating things. Its really a mix and draws on a lot of different areas including the arts. Other museums are looking at that too, doing

> more of that kind of thing. Especially around design and engineering design.

At NYSCI, there appears to be strong interest in the Maker Movement. Two interviewees discussed Maker as another modality of art at NSYCI. They both discussed how often NYSCI's public programming utilizes arts, crafts and project-based learning to connect with museum content and seemed to view the Maker Movement as being mutually inclusive with art. The Maker Movement was of interest to the NYSCI's director, according to an interview participant. Conversely, another NYSCI participant stated that arts "are not the core of activities we are doing." This interviewee went on to say that the museum was more interested in science "or our Makerspace. That is much more crafty than art. We are much more about design."

Additional site-specific spaces. Other areas for the arts were also present at these sites. There are areas, or labs, similar to Makerspaces. However, they are specific to each institution. Interviewees from the Exploratorium indicated the ways in which these spaces are built into the museum. As mentioned in the last section, the Exploratorium has a Tinkering Studio, which is only one of the many ways that museum integrates art. The Exploratorium's website describes the Tinkering studio as "an immersive, active, creative place at the Exploratorium where museum visitors can slow down, become deeply engaged in an investigation of scientific phenomena, and make something that fully represents their ideas and aesthetic" ("About the Tinkering Studio," n.d.). According to an interviewee, the Tinkering Studio is a place that visitors can have hands-on experiences that "emulate a process" by collaborating with a range of facilitators using an assortment of materials. In addition to process emulation activities, the Exploratorium

participants discussed efforts to facilitate conversation and discussion with visitors through their public artwork and cinema public programming.

Participants from OMSI also cited hands on activities led by educators in their science labs as a means to connect art with STEM. Educators create individual activities to accompany concepts on the museum floor. Like Makerspaces and the Tinkering Studio, a wide range of activities and materials are used to support these experiences at OMSI. NYSCI also has a history of educator led activities and special events for audiences to make crafts that illustrate scientific content.

Research Question 3: Challenges of Arts Integration

Themes emerged in the data when speaking to participants about the challenges of integrating the arts in science centers. First, two sites commented on funding as being a challenge for arts integration. Participants also discussed the difficulties that can arise when working with people from a different field with dissimilar terminology.

Funding

NYSCI and Exploratorium discussed funding for arts integration efforts being a challenge. Another participant from NYSCI made this statement during the interview: "I would hope to see more funding…I feel like if the funding were out there, we would be pursing [arts integration]. So I wish there was more." Another participant from the Exploratorium discussed funding:

> Making sure that we have a funding strategy to support the arts [can be a challenge]. It can depend on the cultural and political climate around education at different times…Artists can be controversial, so sometimes that can be problematic if the funder doesn't share the politics of the artists. I think that's one of the biggest issues that can be inhibiting sometimes; I think sometimes we struggle with…

The participant went onto say that, "there were times when the National Science Foundation questioned the value of artists with science learning" and that the Exploratorium addressed this challenge with by hosting the AWK conference. The Exploratorium wants to:

> Try to create an argument and best practices for how to work with artists. How to show that these artworks are effective for learning, because of their popularity, because of the way in which they round out the collection of other exhibits on similar topics. Our approach now is to focus our artworks and make more of them but to also study what happens when we bring an artist into our midst, how do their ideas evolve, what does it take to work with them to realize a great work of art.

Differences in Professional Backgrounds

Case study sites discussed how professional differences between fields has been a barrier, particularly due to a lack of shared terminology.

Working with Artists. Both NYSCI and Exploratorium also discussed how working with artists has sometimes been challenging because artists typically serve a very different audience from science centers. For instance, a participant at NYSCI said that,

> I think sometimes some of the artists we have worked with here, and it's very different coming to this science center, who work with a lot younger of an audience, and introducing artists to this audience particularly when it came to exhibiting work and how incredibly robust for those projects to be in order to be made to be put out on the floor with a really young group of very enthusiastic children who really want to touch and interact with everything physically. And so it's really making the links between the audience who use these science centers to be interactive and hands-on, robust things with big buttons that you can you know, hit really hard and then having the artist come in and realizing 'Okay my work can't be that precious, my work has to be built in a way that will make the same point that I want to make but in a much more hands on, interactive way.

An interview participant at Exploratorium also discussed the challenge that working with an artist can pose. The participant said that,

> Some artists are savvy at making things and able to work with our developers to make sure that what they made was robust and safe enough to go into an environment with multiple users…[There are] things to be worked out between artists and more seasoned exhibit developers to ensure [artists] understand what it means to make something with durability and long term appeal.

Disparate discourse. Some participants mentioned how it can be difficult to navigate between two disciplines. For example, an Exploratorium interviewee explained that, "people talking from different professional contexts. People might have to make these leaps or hear discourse that is not familiar to them or exchange ideas with people that have more conventional background or progressive kind of thinking."

A participant at NYSCI made a similar comment: **"**I think that it is a language and a culture issue. I think that when you have someone coming to your organization who thinks about something in a different way there is sometimes a culture clash that happens." Additionally, a participant at OMSI said **"**it's always a challenge working with people from different fields and disciplines. We don't all speak the same language right away. It takes relationship building."

At the beginning of each interview, sites were asked what term they used to describe the connection between art and STEM. There was inconsistent terminology used to describe arts integration within and between these organizations. There were many terms used to describe the connection between art and STEM in the data. Without being probed specifically about STEAM, all sites referred to this term in different ways. However all but one participant from OMSI said that STEAM was not a term used

consistently by the organization. Ultimately, these sites used multiple terms when asked directly about what word is used to describe the connection of art and STEM.

At the Exploratorium, one participant said:

> I guess we would refer to that specific thing as STEAM. Although we don't use that [word]. I see that as a specific initiative and idea. We would use a broader term for ourselves. Which would be something about art and interdisciplinarity or something like that. I am not sure what phrase we would use. Integrated arts. Art as form of inquiry.

Another interviewee at the Exploratorium stated:

> I think what is key to understand is that we don't have a term we consistently use because we are actively exploring the relationship between art and science. One way we don't talk about it very much is art and technology. We prefer to think about it as art and science as forms of learning or inquiry.

At NYSCI, the word STEAM was also referenced but again it was not institutionally recognized. For instance, a participant stated, **"**I mean, STEAM is used. But we do not have any official terms for it here. It is not something that we…I mean its not widely used. It's not an institutional thing." Another participant from New York Hall of Science made the following statement:

> Well I don't know if anyone likes the STEAM acronym but I suppose that is probably one that you hear very often. I am not sure that it is really a topic that comes up that often. I mean I feel like, we much more frequently talk about design as something that we are trying to connect with science as kind of a basis for learning engineering and science. And so the connection to art…I mean I guess we could talk about STEAM. We talk about Maker, you know. Connecting to the Maker community. I would say overlaps with artists quite a bit. So I guess STEAM and Maker are my answers.

A third participant at NYSCI noted, **"**It's hard to say exactly. It's actually been integrated into exhibits and programs for the whole time that I have been at the museum…so it's hard to kind of answer that question…art/science/technology integration."

The participants at OMSI also referenced STEAM. Interestingly, one participant was certain that STEAM is the "go-to term" to describe it. Whereas another interviewee stated: "Gosh, I am not sure there is a term. Some people use the STEAM thing. I don't know if that's very broadly used at OMSI."

Research Question 4: Assessment of Arts Integration

The sites were asked what metrics they use to measure the success of arts integration in practice. Additionally they were asked how any evaluations, formal or not, inform these efforts. These sites devote resources to research and evaluation. However, to the participant's knowledge there was no systemized assessment of arts integration practices.

Participants reflected on evaluation studies that were related to arts integration, but noted that they rarely offered specific metrics on these efforts. For example, a participant from OMSI said that a summative evaluation of Design Zone was conducted; one of the findings was that there was prolonged engagement within the context of a math exhibit:

> We have a summative evaluation of Design Zone. But it didn't specifically ask about arts integration. So it does not necessarily serve as a metric for that. It was not a goal of the exhibit per say. So we have lots of metrics about age, groups, engaging in mathematical thinking. It was nothing specific in the original goals of the project for arts integration. So it was not really reflected as a topic of the evaluation.

According to an OMSI participant, the evaluation

> Is pretty anecdotal at this point. A lot of evaluation has been done by our educator staff on the spot to figure out what is working and what is not. How to tweak things, and improve them. I do not think we are doing anything at this point to really inform those decisions. The educators have so much experience on the museum floor that the variables can be adjusted on the fly pretty easily.

Similarly at NYSCI, participants could not speak to any formal ways of measuring the effectiveness of arts integration: "I have numbers of who came, was interested, what we did, and visitor comments. But I did not have evaluators in to interview or track visitors. We have done that with other exhibits but not to look at the art integration aspect."

Sites cited anecdotal observations about visitor enjoyment. For example at NYSCI, "the feedback is incredibly positive. Visitors value the experiences, the different perspectives, the different opportunities for engagement and learning. They want more!" Longer stay time by visitors around arts integrated exhibits and activities was also discussed. At the Exploratorium, "anecdotally, we see exhibits that are constantly surrounded by people. We can tell by observational studies they do by tracking visitors, people stay at a little bit longer, and they are very well used." And at OMSI,

> There's a lot in our own observations and from the summative [evaluation of Design Zone] there were very long times for some of the exhibits that involve art and music. I think engagement and enjoyment levels were really high for the target audience. You might say despite that it was a math exhibit. People might think, ah! How could I enjoy a math exhibit? In fact there were high levels of enjoyment and engagement. I think when you consider 2/3 of the exhibit was art integrated with math there is something about that too. A lot of people wanted to come back to the exhibit because it wasn't always the same. You could have many different outcomes with something that was appealing. The way we focused on art and music really lent itself to those kinds of experiences. Anecdotally, yes we saw a lot of that prolonged engagement. [And we saw that in the summative evaluation as well].

However, one participant from NYSCI mentioned that they felt visitors might not understand on-site art installations:

> Most people don't come to a science museum and expect to interpret art. They come because they want to handle things or they want to build things or learn and do. But it requires a different kind of mindset from the visitor. So I think that some of the people that came in and looked at ReGeneration just didn't get it. They didn't know how to related to it because it wasn't what they expected to find when they came to a science museum.

These sites referenced how integrating art at these science centers impacts staff positively. At the Exploratorium "our own staff learns a lot by working with artists. We learn new methods. Our practice gets stronger." Similarly at NYSCI, "I get comments all the time from our security guards thanking me for bringing in these art/science gallery exhibitions because they feel renewed by it. It's very interesting." And at OMSI: "I think from a personal level as someone who enjoys music, visual art, the opportunity to do that in Design Zone was very gratifying."

The Exploratorium is interested in advancing measuring art inquiry and one of the objectives of the CAI is to build the capacity to do so into the museum's initiatives. One participant said,

> Well, we are building it into certain projects…I think that ideally we would work with more researchers, especially educational researchers to understand impacts. But it's a bit of a tricky thing in our area. We haven't quite built up the capacity to do it. So we are trying to figure out how to build that into projects.

CHAPTER 5: Conclusions

This research sought to examine the ways in which three science centers were integrating the arts with STEM learning practices, specifically the strategies, purpose, challenges, and assessment of arts integration in science centers. While the results are not generalizable to all science museums, the themes that are discussed in Chapter Four cut across these three science centers. These science centers perceive value in integrating the arts for visitors' learning; they collaborate with artists and experiment with spaces in which visitors can connect the arts and STEM through design projects. These science centers do not have specific terminology to describe the phenomena of arts integration. Challenges of arts integration are perceived to be working with professionals from different backgrounds due to a clash between discourse and funding arts integration. Additionally, assessment is not specific to arts integration. These results suggest that there are opportunities for future research on arts integration in science center practice. The following sections will discuss the results and opportunities for the museum field to advance arts integration.

Discussion

It seems that based on the work being done, and the meetings between professionals discussed in the literature, that the museum field is becoming more aware of the role that the arts can have within STEM learning practices. Researchers of arts integration have identified many benefits of this approach in formal learning settings (Burnaford et al., 2007, Rabkin & Redmond, 2006). The purpose of arts integration as identified by these science centers is sometimes aligned with the benefits and outcomes that researchers have identified from studies on integrating arts across the curriculum

(Burnaford et al., 2007; Burnaford, et al., 2001; Rabkin & Redmond, 2006). Findings from this research suggest that the primary purpose of arts integration in science centers is to benefit visitors. Participants discussed a variety of arts integration benefits including entry to STEM engagement, deepening understanding of science, and visitors feeling empowered. These benefits suggest that these science centers want to impact their visitors when they engage with art at a science center. However, there seemed to be no differentiation between the intended audiences for arts integration experiences and the typical target audience for other programmatic efforts at these sites.

The forms that arts integration took at these science centers represent a wide variety of strategies to engage visitors. Collaboration was a common strategy for arts integration. Results suggest that an important factor contributing to the development of arts integration projects is collaboration with external professionals from many backgrounds such as the art world, museum world, and STEM sectors. Arts integration research has also shown that this education strategy is a collaborative and community driven approach (Burnaford et al., 2007). While this research cannot say for certain what this area of practice does for a museum's community, it appears that these projects encourage collaboration between the science centers and their communities.

While discussing strategies with these science centers, an interesting trajectory appeared across the sites of how they work with artists and their reasons for doing so. It appears that artists inform science center practices in many ways, such as helping ground conceptual work, and designing programs and exhibitions. In some cases artists seem to inspire science center staff to renew and improve their practices. It also appears that some

of the people responsible at these museums for creating arts integration efforts have a background as an artist and/or considered an artist on staff.

Another trend is the designation of spaces for visitors to design, create, and/or mimic, a process related to STEM. The Maker Movement was not a focal point in this research; however, this initiative was discussed by the science centers informing this study. This is evident from the references to Makerspaces, and other site-specific zones for visitors to engage in design activities. It is also interesting that the concept of design was both thought of as inclusive, and exclusive of the arts in this research by different science centers.

The literature informing this research illustrates that there is dissimilar terminology used to describe arts integration in practice (Burnaford et al., 2007; Harrell, 2010). Findings from this research are similar. It was found that these science centers do not use consistent terminology— even between staff members at the same site. In most cases, the sites seemed to reference STEAM, but went on to use another term, or multiple terms, to refer to the same phenomenon. What is interesting about the use of multiple terms used both within, and between, these organizations was that disparate terminology was also associated as being a challenge of arts integration.

This research did not try to assess the effectiveness of arts integration practice at these case study sites. Rather, it sought to explore how museums are evaluating the impact, and defining the success of, arts integration in practice. All three of these institutions dedicate a great deal of resources to research and conduct visitor studies that contribute to the museum field but did not measure the effectiveness of arts integration specifically. However, there are evaluations at theses sites are designed to assess the

effectiveness of any exhibit or program in terms of active prolonged engagement, visitor attitudes, and visitor use. Anecdotally, it appears, that visitors are responding positively to arts integration.

Opportunities for Future Research

Based off of the findings in this research, there appear to be many opportunities to advance arts integration in science centers. After the completion of data analysis, the following recommendations for the museum field would fill the gaps of what is known and not known about arts integration at science centers, in both a practical and research-based capacity.

The benefits noted by these science centers were high level and in some ways can be considered as impacts of arts integration on visitors; particularly the ideas that arts integration deepens the learning experience and empower visitors. While it is possible that these are outcomes of arts integration, researchers perceive there to be a need for further assessment of this practice to determine its benefits and impacts. Clearer articulation of goals, measurable outcomes, and assessment strategies may help science centers improve these practices and determine how, and in what ways arts integration benefits visitors. Arts integration could theoretically benefit most individuals but it is possible that redefining or identifying audience(s) would also help guide arts integration practice moving forward. Additionally, there was discussion about how these practices are gratifying to museum staff. An investigation into how science center staff benefit from using arts integration may be an opportunity for future research as well.

In terms of future research, the discussions about artist collaboration and artists on staff were particularly intriguing. There are many questions regarding artist involvement

at science centers that linger after the completion of this research such as: should there be best practices for working with artists? How, and in what ways, does an artist at a science center impact museum practice? What does it look like in practice to have full time artists on staff? Or what is the benefit of implementing an artist in residence within an organization?

Maker and STEAM are also emerging trends. These concepts should be explored further, as they are discussed as being both similar and dissimilar to arts integration. The consideration of how an autonomous design process activity impacts a museum visitor may be worth exploring in future research.

A consensus on discourse about arts integration at science centers could contribute to the advancement of this practice. It may benefit stakeholders in arts integration to continue to discuss this strategy in forums that allow for people between disciplines to foster clear communication. It may not be up to the museum field to come to a consensus on one common term or definition for arts integration, but it may ease the communication between stakeholders in these efforts moving forward.

Conclusion

Arts integration is of interest to many professionals. Findings from this study suggest that these science centers perceive arts integration to positively impact their organization's visitors. These science centers also integrate the arts in multiple ways. However, areas such as assessment and the terminology to describe arts integration outlined in this study are important to address in order to advance this practice. In conclusion, arts integration with STEM learning in science centers is an area of practice rife with opportunities for exploration.

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APPENDIX A: Consent Form

I am asking you to participate in an interview that is part of my Master's thesis research at the University of Washington. The purpose of this research is to examine the ways in which science centers in the United States are integrating the arts into science, technology, engineering, and mathematics (STEM) learning practices. Your participation is voluntary, refusal to participate will involve no penalty or loss of benefits, and you may discontinue participation at any time. The interview will be recorded and the audio file will be kept confidential. Any of your direct quotations, comments, or opinions in written in chapters with results and discussions will be shared with you for approval prior to any dissemination of my research. If you have any questions now or in the future, you may contact me, or my thesis advisor, via the contact information listed above. Do you have any questions? Do you agree to participate in this interview?

APPENDIX B: Interview Guide

1. What term does your institution use to describe the connection of art and STEM?

2. In what ways does your institution connect art and STEM?

3. What does your institution perceive to be the benefit of arts integration?
   3a. Who benefits from arts integration?

4. What are the intended goals of arts integration at your institution?
   4a. What messages does your institution wish to impart to visitors when they engage with art at a science center?

5. Why is your institution motivated to integrate art at a science center?
   5a. Who, or what, was the catalyst for starting arts integration?
   5b. When was the first instance of integrating art at your institution?
   5c. Was integration intentional or did it happen organically?

6. What motivates you personally to integrate art into your work?

7. Do specific programs and departments at your organization merge art with their projects? Or is arts integration a priority to your organization?

8. Think about your most recent effort related to arts integration. Can you describe the development process of that effort?
   8a. What external data or resources, if any, do you use to inform your approach?
   8b. Does any literature or theory inform your work? If so, what?
   8c. Do any preexisting visitor studies inform your projects? If so, which studies?
   8d. Do you work with artists or other professionals in your community with artistic training to develop your projects?
   8e. What types of artistic activities are embedded into your exhibits and programming? (i.e. drawing, music, etc.)

9. Who is your target audience for arts integration experiences?

10. In what ways is that audience different from typical audiences for other programmatic efforts at your institution? If so, why is your institution targeting this audience?

11. Do you have any existing metrics to track the success of arts integration? (i.e. evaluation)
    11a. Have you conducted any formal evaluation? If so, in what ways did you use findings to continue, improve or develop new programming?
    11b. How have visitors to your science center responded to arts integration?

12. In your professional experience, what are some of the main challenges science centers face with arts integration?
    12a. Has your institution faced any of these challenges? If so, how has your institution addressed challenges?

13. In what ways is arts integration relevant to your organization's mission?
    13a. In what ways does art support the vision of your institution?
    13b. Does your institution intend to continue merging art with informal STEM learning?

14. What current trends of arts integration at science centers have you seen?
    14a. What future arts integration trends do you foresee at science centers?
    14b. What do you hope to see at science centers using arts integration?