

Current Science in Museums and Science Centers

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Abstract

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People are faced with many science-related issues such as climate change, medical research, and new technologies, but often lack the basic science literacy or interest in understanding how these issues affect their lives. Museums and science centers are addressing this issue by interpreting current science research in their institutions. The purpose of this study was to examine how museums and science centers define and present current science to visitors. Museum professionals at seven museums and science centers were interviewed to understand how they define, interpret, and engage visitors with current science. Results suggest varying definitions of current science. Results also suggest participants use methods that allow for contact with scientists and staff and rapid changing exhibits. Participants have goals for greater visitor interest and engagement in current science after their visit. This research can be useful for museums or science centers looking to pursue or increase efforts in current science.

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CHAPTER 1: Introduction

In recent human history, there has been an increase in issues related to current scientific research, for example scarcity of clean water, climate change, technological advances, and emerging medical research (Jha, 2008; U.S. Global Change Research Program, 2014; Zerhouni, 2008). According to the Environmental Protection Agency, “Since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.13 degrees Fahrenheit per decade” (2010). In 2012, “Cancers figured among the leading causes of morbidity and mortality worldwide, with approximately 14 million new cases and 8.2 million cancer related deaths” (World Health Organization, 2014). More scientists are entering the field throughout the world and are working together to solve these problem (Xie, 2014).

The problem in the United States is there is a lack of science literacy within its citizens. In 2010, adult science literacy was measured to be 28% (Raloff, 2010). For example, only 47% of adults could give an approximation of how much water covered the earth (Clough, 2011, p. 1). In their Science and Engineering Indicators report for 2016, the National Science Board found, “The average science literacy score for U.S. students in 2012 was 497, lower than the average science score of 511 for all developed countries” (p. 1–5). However, the study also measured American interest in science research and found that while Americans may lack science literacy skills and knowledge, they are interested in science and science topics (National Science Board, 2016). In spite of this, there is still pressure for greater public understanding of science (Hilton, 2015; Leshner, 2003; Priest, 2013; The American Association for the Advancement of Science, 2016).

The push for the understanding of current science research has been made at the executive level of the United States government. At the end of the Cold War, Presidential

Science Advisor Vannevar Bush stated the importance “of science in the public interest, the value of science in addressing the critical issues of the period” (Vannevar, 1945). In his inaugural address to the United States, President Barack Obama made a call to restore science and science education to a higher priority (Obama, 2009). President Obama’s call for an increase in science literacy and greater understanding of current science in the United States sets up an opportunity for science museums and science centers to play an important role in increasing the science literacy of the American public (Lowhater, 2009).

One way museums and science centers are addressing this issue is by finding ways to present unfinished, or current science (Hine & Medvecky, 2015). Former Secretary of the Smithsonian Institute, G. Wayne Clough (2011) said museums play a key role in increasing science literacy in their visitors. He argued, “Addressing the gap in public understanding that surrounds science will require the coordinated participation of scientists, educators, parents, media, and public institutions to find clear, compelling ways to communicate science” (p. 2). One of the methods that museums use to introduce audiences to science is public engagement with science, which “refers to activities, events, or interactions characterized by mutual learning” (CAISE, 2009, p.18). Various methods for public engagement with science include face-to-face meetings with scientists in programs like *Portal-to-the Public*, or exhibits that allow for hands-on activities with collections and research like *Q?rius* at the National Museum of Natural History in Washington, D.C.

There is literature that describes the nature of current science, the importance of current science, and how it is presented to visitors to informal science education institutions (ISEs). Literature in the field suggest that public engagement with science is increasing in informal science education institutions and we are discovering more about the outcomes of this

phenomenon with the public, scientists, and the ISEs interpreting this content (American Alliance of Museums, n.d.; Bell, 2009; Durant, 1992; Feder, Shouse, Lewenstein, Bell, & others, 2009; Institutue of Museum and Library Services, n.d.). There are also challenges surrounding efforts to present current science in ISEs. Finally, while there is literature describing field-wide goals for visitor engagement with current science, there appears to be no indication to specific institutional views of definitions of current science.

The purpose of this study is to examine how museums and science centers define and present current science to visitors. The following research questions informed this study:

1. How do museums and science centers define science?
2. What methods are museums and science centers using to present current science?
3. What do museums and science centers want their visitors to get out of their experiences with current science?

Research into how science museums and science centers define and present current science is critical. The seven institutions in this study are focused on the presentation of science for the benefit of the communities they serve. Other science museums and science centers interested in introducing or expanding current science topics within their institutions can look to these seven institutions as examples for thinking about current science, how to present it, and goals for visitor engagement. Researchers can also gain insight into museums and science centers presenting current science to inform future studies that provide a broader look at visitor outcomes from current science experiences and more museum and science center staff perspectives into perceptions of current science. This can help the field better understand the role that museums are playing in increasing the science literacy of the public.

CHAPTER 2: Literature Review

This study is situated within related research that is focused on current science and how it is presented in museums, as well as how museums typically engage audiences with science. This literature review seeks to describe the nature of current science and its relationship with museums, define public engagement with science and how it has developed, and outline what is known about the effectiveness of interpretive methods science museums use to present current science to public audiences.

Current Science in Museums

The National Aeronautics and Space Administration (NASA), a governmental agency, defines science as “curiosity in thoughtful action about the world and how it behaves” (National Aeronautics and Space Administration, n.d.). Science helps us understand the world and how it works. Scientists use methods to hypothesize ideas, and test those ideas using experiments and observations. Those ideas are then established as fact and can be tested over and over to determine if they still stand. Sometimes, these ideas change and new ideas and observations of these ideas can change prevailing theories (Rutherford & Ahlgren, 1990). An article from *Dimensions* magazine by Buckler (2015) states that “many of the world’s most pressing issues are science based, including climate change, disease, energy transitions, food security, water allocation, pollution, and mass extinction” and that science centers and science museums are “being recognized by our communities as the ‘go-to’ sources of information on today’s critical global issues” (para. 4).

Scientific research can be broken into two categories: established science and current science (Durant, 2004; Selvakumar & Shugart, 2015). Established science typically refers to science involving studies that are complete, often the societal implications are clear, and spend

little to no time debating the topic (Selvakumar & Shugart, 2015; Durant, 2004). Durant (2004) states that established science “emerges as a fixed body of knowledge and practice, more or less totally beyond either doubt or dispute” (p. 51). In contrast to established (finished) science, current (unfinished) science is described this way:

By contrast, the phrase, “unfinished science” denotes what is essentially a sociological distinction between scientific claims and conclusions that are settled to the scientific community (finished science) and scientific claims and conclusions that, for whatever reasons—the novelty of the subject matter, the availability of new research techniques, the absence or inconsistency of evidence, the paucity of theory—are unsettled within the scientific community (unfinished science) (Durant, 2004, p. 53).

Durant (2004) argues there is no clear boundary between established and current science, because sometimes even established science can be disputed and changed.

Today, there are various governmental agencies and not-for-profit institutions that work to advance current science and support the aspirations of museums and science centers to accomplish this goal. The mission of the National Science Foundation (NSF) (2014) is to “promote the progress of science” (p. 3). The American Association for the Advancement of Science (AAAS) (2016) seeks to advance innovations in science and innovation for the world. AAAS supports science museums and science centers through its Center for Public Engagement with Science & Technology by providing resources to science institutions for creating meaningful conversations with visitors. The American Alliance of Museums (AAM) recognizes that “Millions of Americans of all ages and backgrounds learn about science, technology, engineering and mathematics (STEM) each year by visiting museums, science centers, public gardens, zoos and aquariums” and supports these institutions by recognizing that STEM education is an issue facing museums and science centers today (American Alliance of Museums, n.d., p. 2).

Science museums are places for people to gather, socialize, and learn by their own choosing, with topics that include current science. The Association of Science-Technology Center (ASTC), a not-for-profit organization that supports science and technology centers, has stated “Science centers and museums are uniquely positioned to raise awareness, understanding, and interest levels in science and the other STEM disciplines” (Association of Science-Technology Centers, 2013, p. 7). Kuslansky and Peduto (2013) argue “science centers can leverage the technological opportunities of our time to reimagine their role in society, generate innovation, and promote positive social change” and can also “attract a broader adult audience by championing emerging technologies” (pp. 31–32). Many of the ideas related to science museums and current science involve social issues and dialogue surrounding social issues:

Science centers and museums are preparing a new generation of responsible global citizens who will be able to address the problems that will face our world over the next century. From air and water pollution to endangered species to human health and nutrition—these challenges demand global solutions that reach beyond geopolitical borders (Association of Science-Technology Centers, 2013, p. 8).

Science museums think about how to engage the public in current science. An example for how science museums accomplish this goal is provided by Bell (2009) who recommends three approaches for science museums engaging the public with science-and technology-related policy: “1. Providing social science context for science issues, 2. Becoming forums for dialog and debate, and 3. Providing mechanisms for public views to be shared with scientists and policy makers” (p. 25). This sets the path for science museums to be able to engage the public with science, particularly with current science.

Public Engagement with Science

Public Engagement with Science (PES) is a current trend in informal science intended to allow audiences to participate in science and technology. The American Association for the Advancement of Science defines PES as,

intentional, meaningful interactions that provide opportunities for mutual learning between scientists and members of the public. Mutual learning refers not just to the acquisition of knowledge, but also to increased familiarity with a breadth of perspectives, frames, and worldviews (para. 1).

This model for learning involves two-way learning between the participants and scientists. The participants, or non-experts, are said to become science literate, meaning that upon engaging with interactions in PES, they will have the “ability of citizens to read about, comprehend, and express opinions about science” (Allum, 2010, p. 725). The Department for Innovation, Universities & Skills (2008), now part of the Department for Business, Innovation & Skills in the United Kingdom, defines PES as occurring via “science centres and festivals, through information provision by consultation, active dialogue and other media, to enabling citizen empowerment and decision-making” (Department for Innovation, Universities & Skills, 2008, p. 3). In the field of science, “researchers and research organizations are being called on to engage with the public as a way to communicate current science” (Selvakumar & Shugart, 2015, p. 14). Chittenden (2011) argues informal science education institutions, such as science museums, science centers, aquariums, botanical gardens, nature centers, zoos, and planetariums can bring “strong institutional capacities, educational expertise, and community-wide impact to support increased public engagement in current and emerging science” (p. 1550). Chittenden (2011) also argues PES “seeks to bring together those who generate scientific knowledge, those who affect its use, and those who, perhaps unknowingly, experience it in daily life to discuss the social, cultural, and ethical aspects of science” (p. 1553). PES can do more than convey science

knowledge, going further to provide a greater understanding of science issues, controversies, and how PES can contribute to people's understanding of science and the role it plays on society (Chittenden, 2011).

Scientists and science and technology institutes state the goal of public engagement with science is to engage citizens in current and emerging science, as opposed to established science topics (Guston, 2014). Non-scientists can deliberate over emerging technologies and research, and this understanding of science can create conversations relevant to the needs and values of citizens (Guston, 2014). A report by the Center for the Advancement of Informal Science Education (CAISE) (2009) argues that institutions of informal science education can “provide opportunities for public awareness of and participation in science and technology” (p. 11). The CAISE study was conducted to assess how PES within informal science education (ISE) can help visitors to ISE institutions participate in science and technology. This foundational study comes at an opportune time for informal science education institutions. There is a need to research the extent to which public engagement with science is actually getting the public engaged in science and science learning (Whitehouse, Waller, Chanvin, Wallace, Schel, Peirce, Mitchell, Marci, Slocombe, 2014).

Public Engagement in Science may help “shape innovation trajectories, strengthen the public value of technologies, and open up new spaces for political leadership” (Chittenden, 2011, p. 1553). Public Understanding of Research, a branch of Public Engagement with Science, can provide an opportunity for Informal Science Institutions “to present cutting-edge research while helping public audiences understand the process of scientific research” (Selvakumar & Shugart, 2015, p. 6). If an issue is more controversial and has the potential to cause emotional reactions from the public, then institutions are poised to provide information with little bias (Selvakumar

& Shugart, 2015, p. 6). Science museums can typically provide dialogue on topics such as climate change, GMOs, and nanotechnology.

A precursor to public engagement with science, public understanding of science, was guided by the belief that citizens would have a better relationship with science and greater trust with science experts if they understood science (Haywood & Besley, 2014). This was typically an expert teaching the lay citizen without providing much room for dialogue or conversation. This so called deficit model was common until the early twenty-first century (van Est, 2011). Recent efforts have been put forth to allow for more participation in science, increased deliberation on topics, and greater understanding of the scientific process more than scientific content (Haywood & Besley, 2014). Public engagement programs have increased in diversity since the early 2000's (Selvakumar & Shugart, 2015, p. 7).

Museums have a connection to their communities and are “unique physical spaces that bring together collections of historic objects or experiences” (Selvakumar & Shugart, 2015, p. 5). Science centers and science museums can engage these communities in science learning (Chittenden, 2011). Typically these museums and centers “present ‘known’ science and its well established core concepts and principles, rather than ‘unfinished’ science and new research” (Chittenden, 2011, p. 1550). Due to their social nature, museums have the potential to create a greater public engagement with science effort across the country (Chittenden, 2011; Selvakumar & Shugart, 2015; Sanchez-Mora, 2014). These institutes have been able to achieve high prominence in science education, research, and policy (Feinstein & Meshoulam, 2014).

Recently, science museums have started to present more current science, but more needs to be done by “rethinking institutional priorities, operational models, and community service aspirations” (Chittenden, 2011, p. 1551). Museums need more support to be “courageous,

intentional, and creative in involving the public in voicing their perspectives, concerns, and issues around science and technology” (Chittenden, 2011, p. 1556). By this, Chittenden means that museums need to take risks in allowing spaces for discussion with science and technology. While some issues may be difficult and controversial, others do not have clear answers and are a little murkier.

There are many challenges in engaging the public with science. Programs need “extensive staff effort to plan and conduct and, because attendance is often limited, they cost more per participant than standard programs” (Chittenden, 2011, p. 1551). Another challenge is not to talk about impact on science policy, science knowledge, and attitudes about science (Guston, 2014). This is also problematic for informal science education, because it is not only personal and contextual, but also time-consuming (Sanchez-Mora, 2014). One other problem that science museums face is the general nature of how museums operate. Many museums and science centers do not operate such programs because they do not always fit in with the mission of the institution (Chittenden, 2011). Science museums and science centers that are admissions-driven usually need to schedule blockbuster exhibits to increase revenues, causing scheduling issues for programs for public engagement with science as well as little support that usually have lower attendance and high costs (Chittenden, 2011).

Interpretive Methods for Current Science in Museums

In public engagement in science programs, the participants can gain new understandings of issues in science, which is “not reflective of the public’s scientific or technical knowledge, but rather on the public’s wisdom and knowledge drawn from their life experiences, buttressed by their personal and community values” (Chittenden, 2011, p. 1553). With the emergence of the more active, public engagement programs, there is a continuum of engagement where along the

deficit model side “passive recipients are viewed as empty vessels to be filled with knowledge, and therefore a transfer is needed; to the interactive model, where active learners are viewed as experts in their own right, whose experience is recognized as a valid way of knowing” (Yaneva et al., 2009, p. 79-80).

Museum exhibitions are meant to exhibit objects and information to allow learning for visitors (Dean, 2001). An example of this is Q?rius—pronounced “curious”— an exhibit space at the Smithsonian National Museum of Natural History that presents collections, science, and researchers to public audiences, aimed mostly for teens and pre-teens (Barry, 2014a). Visitors walk in, learn about research that is currently being conducted with the institution and visitors are allowed to handle real and reproduced museum collections. Teen and adult volunteers are present to interact with visitors in the space. In 2013, the Oakland Museum of California opened its Gallery of California Natural Sciences, which discusses biodiversity between humans and nature, as well as environmental issues within California. Part of the preparation for the gallery space included consultations with scientists on these issues (Barry, 2014b).

Public Participation in Research allows audiences to actively participate in research by using the scientific method, learn both science content and the process of science, and understand how the science process can benefit society as a whole (Selvakumar & Shugart, 2015; Haywood & Besley, 2014; Simon, 2009). Besides public involvement with the process of science, a goal of Public Participation in Research is to create intentional interactions between professional scientists, policy makers, and everyday citizens (Haywood & Besley, 2014). Citizen science allows for non-scientists to participate and contribute to scientific research through science museums and centers (Gupta et al., 2014). Typically, citizen science projects involve

participants to collect data for ongoing science projects. Projects can involve anything from studying bird populations to testing the water supply in one's own community

Science Cafes are typically put on by science centers and science museums. Scientists are brought into cafes, bars, pubs, or any casual location to have scientific discussions. Scientists usually provide content and then people are allowed to discuss content to understand contemporary science issues (Cohen & Macfarlane, 2007). Participants may not usually be involved with such discussions in museums; science cafes provide a comfortable space in an informal setting (Selvakumar & Shugart, 2015, p. 11).

A model for public engagement with science recently appeared within the field of informal science education. Portal to the Public, or PoP, "brings active researchers and other science professionals into museums to interact directly with visitors on their current research" (Selvakumar & Shugart, 2015, p. 14). PoP was started by four informal education sites; the Pacific Science Center, the North Museum of Science and History, the Institute for Learning and Innovation, and Explora; PoP was intended to provide a framework to allow scientists to gain science communication training to communicate their research to nonexperts. Scientists participate in workshops to be able to identify what made learning about science memorable to them and allow them to utilize these experiences to their advantage own interacting with the public (Selvakumar & Shugart, 2015).

Summary

There is research around what current science is and how it is presented in science museums. There is also a push for museums to participate in Public Engagement with Science, to allow visitors to be more informed citizens of science. Finally, there are examples of methods that utilize PES. What is unclear in research is how science museums that present current science define and think about this phenomenon and why they choose certain methods to present current science.

CHAPTER 3: Methodology

The purpose of this study was to examine how museums and science centers define and present current science to visitors. This study was guided by three research questions:

1. How do museums and science centers define current science?
2. What methods are museums and science centers using to present current science to the public?
3. What do museums and centers want their visitors to get out of their experiences with current science?

To address these questions, this study was designed as a qualitative, descriptive study. This chapter describes the study's methodology, including sampling, data collection, data analysis, and limitations.

Sampling

Research Context

Participating museums were chosen using the following criteria: physical locations that included educational programming and exhibitions centered around current science; identified via the Portal to the Public network, in the literature, or by other museum professionals, as sites that are actively attempting to address current science. Portal to the Public was chosen because this provided at least one consistent current science effort by the institutions being studied; one that involves scientists and the public interacting. The Museum of Science, Boston and the Science Museum of Minnesota are not in the Portal to the Public Network, but were identified through their work in the literature. A total of 18 such institutions were identified and contacted; 9 responded and agreed to participate in the study, 7 actually participated in the study while the

other 2 institutions did not go through with the study. No reason was given, communication with the institutions simply ended.

The seven participating institutions were the Koshland Science Museum in Washington, DC; Morehead Planetarium and Science Center in Raleigh, North Carolina; the Museum of Life and Science in Durham, North Carolina; the Museum of Science, Boston in Massachusetts; the Pacific Science Center in Seattle, Washington; Science Central in Fort Wayne, Indiana; and the Science Museum of Minnesota in St. Paul. Five institutions are part of the Portal to the Public Network, with the exception of the Museum of Science, Boston and the Science Museum of Minnesota. For context, Portal to the Public is a framework for Informal Science education institutions to use bring scientists and the public together.

Background information on participating institutions was pulled from on their respective websites. The Koshland Science Museum was created by the National Academy of Sciences, a national non-profit organization that supports science research. The Koshland Science Museum's mission is to "engage the general public in current scientific issues that impact their lives." Efforts for current science at Koshland include online interactive exhibits such as their "Extreme Event: Building Disaster Resilience" which are activities that help people understand disaster resilience, exhibits that help visitors understand climate change such as the *Earth Lab* and galleries that help people understand themselves such as the *Life Lab*, an exhibit dedicated to teaching people how to take care of their bodies. From interviews, the researcher gathered that volunteers generally interact with visitors to get them engaged with exhibits. Many volunteers can be scientists or people who are not scientists

Morehead Planetarium and Science Center is different from the other sites because it is located on a university campus, the University of North Carolina in Chapel Hill. The mission of

Morehead is “to serve North Carolina and beyond by bringing together the unique resources of UNC to engage the public for an improved public understanding of science, technology, and health.” Morehead utilizes exhibits, programs, and even planetarium shows to present current science to public audiences. Exhibits include discussions on accessibility to clean water and astronomy. Programs include Science Cafés for teens and general audiences and stargazing, and programs that introduce younger audiences to STEM such as STEMville science symposium. Planetarium shows include discussions on topics like black holes, the earth, and the skies over North Carolina.

The Museum of Life and Science’s mission is to “create a place of lifelong learning where people, from young child to senior citizen, embrace science as a way of knowing about themselves, their community, and their world.” The interviewee from the Museum of Life and Science talked from the point of view of the museum and from the point of view of his other organization, the National Informal STEM Education Network (NISE Network, formerly the Nanoscale Informal Science Education Network). The Museum of Life and Science has exhibits dedicated to visitors understanding the ecology of North Carolina, such as *Carolina Wildlife*, all the way to letting people manipulate the world around them in exhibits like *Contraptions*. There are programs at the Museum of Life and Science that allow people to tinker, such as *Tinkering and Drinkering* for adults.

The Museum of Science, Boston is different from five of the case sites because it is not part of the Portal of the Public network. The mission of the museum is to “play a leading role in transforming the nation’s relationship with science and technology.” The Museum of Science, Boston has exhibits like the *Hall of Human Life* that asks visitors to think about the implications of scientific research. There are programs that utilize forums for the public to better understand

scientific research, an example of this is one that occurred in June 2016, *Should We Engineer the Mosquito?* The Museum also utilizes live demonstrations from educators and scientists from outside the museum.

The Pacific Science Center has a mission to “inspire lifelong interest in science, math and technology by engaging diverse communities through interactive and innovative exhibits and programs.” The Pacific Science Center is one of three founding sites for the Portal to the Public Network. The Pacific Science Center has two spaces where topics on current research are presented in exhibit format, *The Studio* and *Portal to Current Research*. Both are high turnover, where topics change once every six months. Once a month, the Pacific Science Center also hosts their *Meet-A-Scientist* program where visitors can meet face-to-face with local researchers who have undergone training to present their research to visitors. There are also their research weekends that are larger scale versions of their *Meet-A-Scientist* program. The Pacific Science Center also uses Science On a Sphere, a sphere where projections of Earth, planets in the solar system, and the moon can teach visitors atmospheric and space sciences.

The mission of Science Central states “Science Central is a regional resource that provides inspiring and fun hands-on science education for people of all ages.” Science Central has live demonstrations from educators on their science center floor. They also have Science On a Sphere, and are part of the Portal to the Public Network. There are demonstrations that teach science topics as well as engaging with scientists.

The mission of the Science Museum of Minnesota is to “Turn on the science: Inspire learning. Inform policy. Improve lives.” Like the Museum of Science, Boston, the Science Museum of Minnesota is not part of the Portal to the Public Network. Exhibits include the *Experiment Gallery* which allows visitors to conduct experiments as a scientist would and the

Race: Are We So Different? Exhibit which looks at the idea of race, as well as the science of human variation. An example of a program is *Making Connections Saturdays* where visitors meet and work with scientists and artists from the area.

Professional Participants

Individual interview participants were required to be museum professionals who were employed within the institution at the time of the interview. Participants were approached based on their familiarity and involvement with the museum's educational programming and exhibitions on current science. Names of museum professionals were provided to the researcher by other museum professionals as experts and being knowledgeable in presenting current science to public audiences. Names were also provided by participants' home institution upon initial contact with the museum.

Potential participants received an initial email with a brief description of the study's purpose, the process of the interview, and an explanation that their involvement was completely voluntary and may have ended at any time. The researcher provided participants in the study with information about himself and his role as a student, the purpose and nature of the research, the methods and means of dissemination, and primary questions. In all, 13 museum professionals participated in an interview across the 7 sites.

Data Collection

Data were collected using semi-structured interviews. Interviews were scheduled based on participants' availability. Interview questions were divided into three sections: a) the definition of the participants' definition of current science and their respective museums' definition of current science; b) the interpretive methods for presenting current science the museum uses; c) and their museum's goals in representing current science to visitors (see

Appendix A for the interview guide). Interviews typically lasted between 30-60 minutes. All interviews were digitally recorded. Two interviews were conducted in person, both were with individuals from the Pacific Science Center, and all other interviews were conducted via telephone. One individual was interviewed at two sites (the Museum of Life and Science and Science Central.) Two people were interviewed in a group interview at three sites (Koshland, Morehead, and the Science Museum of Minnesota.) One three-person group interview was conducted at the Museum of Science, Boston.

Data Analysis

Data were analyzed using emergent coding from transcripts of the interviews (Patton, 2002). Seven key themes emerged from the interviews and were organized by research question. Within each theme, sub-themes emerged that further described each theme. Interview responses were coded using a coding matrix designed by the researcher, and reviewed by a critical friend (See Appendix B for the coding matrix). All interviews were reviewed and coded using this rubric.

Limitations

Seven institutions were interviewed for this research study, which places limitations on the generalizability of the results. Due to the scope and nature of this study, field-wide conclusions cannot be made. One to three participants were interviewed from each institution, providing only a small perspective for each institution's views on current science. Future studies can focus on interviewing more science museums and science centers as well as more staff from each institution. This study did not take into account other informal science education institutions that interpret and present about current science, such as natural history museums, aquariums,

zoos, and botanical gardens. Future studies can focus on one type, or comparative studies of different types of ISE institutions.

CHAPTER 4: Results and Discussion

This chapter describes the results of this research study, which are organized according to the key research questions. This chapter is dedicated to explaining the results of the study detailing major themes found under each research question. The themes identified in this chapter are informed by the specific questions asked of the interview participants.

Research Question 1: Definition of current science

All participating institutions in some way discussed current science and how it was represented within their home sites. Only one participant stated they had an institutional definition for how they represent current science. All other participants talked about how current science was discussed within their respective institutions, either everyday through planning meetings or informally. Two key themes emerged in answer to this research question: a) overall there was no formal definition at the participating institutions, with the exception of Morehead Planetarium; and b) participants reportedly draw from various sources to inform how they think about current science.

a) Think about current science in a variety of ways

Most participants did not state a formal definition for current science, however results suggest a variety of different ways in which these institutions think about current science. The one participant that explicitly stated they have an organizational definition for current science, Morehead, defined current science as, “related to the frontiers of science research as well as today’s events and issues.” To come to this definition, one interviewee stated they had a working group of staff develop a definition for several months.

More common amongst participants were context-specific conversations about aspects of current science within their institution. For example, Koshland participants said they think about

current science in the context of the National Academy of Sciences (NAS), the institution that created Koshland. One interviewee stated the NAS has a lot of standards that are not formally written, but, “the NAS considers itself a body that produces scientific opinions and information that is based on published and reviewed scientific information.” Koshland participants said they look to this published information from the NAS to inform their interpretation of current science.

Similarly, the participant from the Museum of Life and Science said his thinking about current science was largely related to his work with the NISE Network, the National Informal STEM Education Network, formally the Nanoscale Informal Science Education network. The participant said that he thinks about specific topics when thinking about current science, topics such as nanotechnology. He said, “We knew that it was going to be an issue of something that museums hadn’t really faced in the past.” He later said the Museum of Life and Science and NISE Net were ready to face this issue.

The Museum of Science, Boston and the Pacific Science Center both do not have specific operating definitions, but when giving a definition of current science, participants included a specific reference to STEM (science, technology, engineering and math). One interviewee from the Museum of Science described current science as “science related to research that is currently happening or very recently published and relevant to the public in general for any number of reasons.” The Museum included engineering in this definition, something that was not huge in the museum but is now a high priority. One interviewee from the Pacific Science Center stated that current science “goes beyond science. It goes to STEM. I think it also goes to applications. What people are doing in the health field, technologies...” Another interviewee from the Pacific Science Center discussed how current science was talked about everyday within the exhibits department:

Science centers everywhere right now are figuring out how to be relevant to their communities. We also live in a really interesting time in human history. We have some big problems we're facing, and science and all that's represented in science is a key piece of how to navigate some of these big problems that we have.

Participants from Science Central and the Science Museum of Minnesota both stated that current science had an obvious definition. The interviewee from Science Central said, "I think it's self-explanatory. I think current science is scientific research, breakthroughs, technology that is being presented to both scientists and or the general public." One staff member from the Science Museum of Minnesota said, "Obviously, science is always a work in progress, right?" There were discussions on how to present current science at the Science Museum of Minnesota, and while there was no specific definition mentioned, one staff member stated, "Being able to get a definition out there that visitors could relate to...we needed this really flexible, definite, that still had these clear buckets that stories could fit into."

A few participating sites talked about a balance between presenting current and established science. The participant from the Museum of Life and Science talked about established science as "anything we've known to be true for years." In relation to the balance between presenting established and current science, he said established science, "is something that museums typically cover more, in fact probably quite a large percentage of 3museum exhibits and programs deal with established science." A participant from the Science Museum of Minnesota discussed when it was best to present current versus established science. To him, it was sometimes necessary to present established science to add context to the topic. He said, "We often times try to piggy back current science stories." They piggy back these current science stories on top of established science topics to help create a balance in presenting both kinds of science. The participant from Science Central talked about presenting both current and

established science, but more from an interpretive point of view. He said, “Whether it’s current or non-current science, we have hands-on, interactive exhibits.”

b) Defined from various sources

All sites mentioned at least one source of information that shaped how they think about current science. Often, information came from within the institution. Participants from Koshland, the Museum of Life and Science, and the Museum of Science, Boston all stated the way they think about current science was influenced by the way the institution thought current science. Both staff members interviewed from Koshland said that they pull their definition from working at Koshland and with the National Academy of Sciences. The participant from the Museum of Life and Science said that working with the Museum and with NISE Net contributed to how he thinks about current science. He said, “It’s a culmination of working in the field of nanotechnology education that helped shape my understanding of what current science is.” One interviewee from the Museum of Science stated that she was influenced by colleagues at the Museum. She said, “It has to do with how the museum was already thinking about it.”

Staff from both the Pacific Science Center and Koshland talked about their own professional backgrounds and how those influenced how thought about current science when they joined their respective institutions. The participant from the Pacific Science Center talked about their background as a scientist: “I’m a research astrophysicist by training, so I come from current science.” The participant from Koshland said, “having exposure to science in my undergraduate studies” taught her about scientific journals and the nature of science.

All participating institutions were influenced by their work with researchers and research sites. Koshland was influenced by the research that comes from their parent institution, the National Academy of sciences. One staff member said, “All of our exhibits are based upon

information that has come from NAS reports.” Science Central was influenced by their relationship to research sites, including governmental research organizations. The participant from Science Central said, “We have a very strong connection to NOAA [National Oceanic and Atmospheric Administration] and NASA [National Aeronautics and Space Administration].” Morehead talked about their interactions with researchers on a daily basis. A participant from Morehead said they use “some of the resources the university produces.” The Museum of Life and Science talked about research coming out of labs, bringing out the nuances of scientific research, what is known and what is unknown, and the work researchers are doing to solve the unknowns. Many of this comes from the Museum’s, and in extension NISE Net’s, relationship with local research sites. To cultivate these relationships, the interviewee discussed how important it was to reach out to scientists and research sites. He said, “I spent a lot of time reaching out to scientists in the area trying to get them to understand what the museum is and how we’re trying to incorporate more current science into our programming efforts.”

The Science Museum of Minnesota has local and national partnerships. One participant said, “We had lots, and lots, and lots of partnerships with academics all over the country, but especially here in Minnesota.” The Museum of Science looked at not only at research coming out of labs, but research, that “connects to things that people want to know about and are interested in.” The Pacific Science Center talked about their process of identifying topics for exhibits and programs to talk about and finding expertise within the community to inform the topic. One interviewee discussed how the Pacific Science Center relied on research from the community to fill in gaps of expertise within their institution. He said how this was true of all informal science education institutions that, “No one institution can be an expert in all areas of science.”

A few participants discussed some form of publication or media, digital or print, that they look to when pulling information for current science. A participant from Morehead said, “We all read professional journals and popular publications.” The Museum of Science discussed the recent nature of current science. One participant said, “We have this general guideline that if you could find a paper or news article that talked about the topic you were covering from the last six months, we consider that current.” The participant from the Museum of Life and Science talked about staff that are part of listservs, research organizations, and even look to social media such as Facebook or Twitter for current science. In relation to social media, the participant said it was important to “follow the right people.” One participant from the Pacific Science Center talked about how they look to headline news to inform current science content in their exhibits. She said, “almost every current science exhibit we’ve done is headline news.” The Science Museum of Minnesota talked about popular science publications and even other informal science education institutions. One participant said, “We relied on plenty of stuff like *Nature* and *Science*, and the American Museum of Natural History...” she said AMNH had a program that published current science from the perspective of the museum.

Participants from the Science Museum of Minnesota talked about crowdsourcing content for current science topics. They talked about their web platform, *Science Buzz*, a website that presents articles and interactives on current science. *Science Buzz* also has a presence on the floor of the museum, via portable stations that generate content directly from the website. One participant talked about how much of the content on *Science Buzz* was user generated. Visitors ask questions, post to blogs, and conduct web searches on the website. One participant said, “We could just see what people are searching for.” She said this method allowed them to gauge public interest in current science.

Research Question 2: Interpretive methods for presenting current science

Participants were asked what methods were used when presenting current science.

Participants discussed methods that involve: a) face-to-face interactions with scientists; b) Rapid change exhibits; c) Programs led by staff; and d) Programs that allow for the bi-directional nature of science and understanding to occur.

a) *Face-to-face with scientists*

All participants stressed the importance of utilizing methods that allow for face-to-face interactions with scientists. The participant from the Museum of Life and Science discussed the benefits of contact with scientists for both the visitors and participating scientists. He said, “I think it’s also important for the public to meet those people. And maybe they relate to them, because that scientist is a person of color or is a female, and inspire new people who may not feel they have an opportunity in the sciences.” As for the benefit to scientists, the participant wanted “scientists [to] begin asking questions of the public instead of just disseminating their research.” He hoped this feedback from visitors gives scientists ideas for where to direct their research.

Participants from The Museum of Science, Boston talked about their volunteers who are or were scientists. For them, it was more about interpretation than just about presenting their research. They described one program that allowed visitors to participate in scientific research as human subjects in sociological studies. According to one participant, for scientists to be able to participate in the program, “it’s required that these people actually translate their science for the public.” To the Museum of Science, having scientists interact with visitors has “a personal connection to it.” This was further confirmed by the Pacific Science Center. Both participants talked about the importance of programs that allow visitors to interact with scientists, such as *Meet-A-Scientist*, a handful of scientists present research on Saturday through hands-on

interactive activities, Research Weekends, which are larger scale *Meet-A-Scientist* programs, and science cafés, which are forums with scientists at local businesses. One participant said, “People really appreciate that you’re talking to a real scientist.” Like the Museum of Life and Science, there was a benefit for scientist as well. The other participant said, “Scientists feel empowered. They feel they can explain their work. And for some of them, it’s the first time they’ve been able to explain their work.” Science Central wants their scientists to have this empowerment as well. The participant from Science Central said they want scientists “to take their research and explain it in a way that a family or school group would understand.”

Participants stated that contact with scientists allow for visitors to better understand who a scientist is. A Koshland participant said that their visitors get, “to see real life scientists that are working in STEM careers...” She said their visitors trust the authoritative voice of scientists and how the experiences with visitors were more authentic. The Museum of Life and Science and the Pacific Science Center talked about changing people’s perceptions of scientists. The participant from the Museum of Life and Science wanted these interviews to break down stereotypes of scientists. He said this happens because the public knows “who and what a scientist is and how the public should and can play a role in whether or not [what] technologies are adopted.” The Pacific Science Center discussed the importance of humanizing scientists. One participant said, “One thing we really thought was for people to understand that scientists are, to a large extent, like everyone else...it humanizes the nature of science and the nature of people who do science.” Through these efforts people can feel more receptive to science and participating in science.

Participants discussed the collaborations their institutions have with scientists. The Pacific Science Center spoke to the importance of building relationships with scientists. One participant said, “It’s a way of thinking about how you build relationships with scientific

institutions and scientists.” Koshland discussed the future of collaborations within the National Academy of Science. One participant said, “One of the possibilities for moving forward is that the museum becomes more of a collaborative space between ourselves and other groups that the NAS has, one of which is the Cultural Program...the other program is the NAS Tech Futures initiative.” She said both programs look at the intersection of art and science. Morehead and Science Central talked about continuing collaborations with scientists after future expansion of physical space and programming. Morehead talked about their renovations for a gallery that will focus on current science. One participant said, “We’re going to be directly addressing current science that is being done by researchers at UNC.” Science Central talked about how they wanted to expand programming with science. The participant said, “We want to continue to work with our local university professors, both the ones that we’re currently working with as well as new one.” The Museum of Life and Science talked about the benefits of having scientists come to help them present current science. One staff member said scientists “help us facilitate these activities.” Both the Museum of Science and the Pacific Science Center have the *Living Lab*. According to one staff member from the Museum of Science, the *Living Lab* is a space “where researchers who are doing research can come into the museum and actually use visitors as data.”

b) Rapid change exhibits

Participants discussed the importance of exhibits that have high turnover for exhibits. One of the challenges mentioned by the Pacific Science Center was trying to deliver interactive experiences in exhibits. One staff member asked, “Is there a way for us to deliver current science that’s not a video that is as nimble as our 500 sq² spaces, but perhaps with only interactive. I don’t have those answers because we’re figuring that out right now.” Those 500 sq² spaces are

The Studio and *Portal to Current Research*. They allow for quick turnover of current science being presented in on the floor of the science center.

Both the Museum of Science and the Science Museum of Minnesota talked about incorporating dialogue as a way to help getting visitors thinking about science in their exhibits. According to one participant from the Museum of Science, “We have a provocative questions exhibition, which takes a socio-scientific topic where people can discuss the societal and ethical implications around questions and create an argument through conversation.” The Science Museum of Minnesota discussed scenario games that were part of their *Science Buzz* website where people could respond to a topic with some sort of controversial topic. People were allowed to comment on each other’s responses, but also talk with staff from the Museum. According to one interview participant, “We expanded a lot with the idea of inviting visitors into the conversation and more than just allowing them to respond to us, allowing them to create situations where we had to respond to them.”

Many of the challenges related to rapid turnover exhibits are the resources involved in changing content. Morehead talked about how it is easier to create programs with current science over exhibits and digital planetarium shows. According to one participant, “exhibits take more money and more time.” And another, “All around, our programs are just easier to accommodate current science.” To solve this, Morehead had a grant from the National Science Foundation that allowed them to create a template for quick turnover of current science. There was not one created, but it was an endeavor that Morehead is still interested in pursuing.

The Pacific Science Center talked about the expenses related to turning over two exhibit spaces related to current science, training staff and scientists, and maintenance funds for programs. An interview participant said they were “looking at different models of funding” that

will help cover costs after the grant money runs out. According to one interviewee from the Pacific Science Center, “Presenting current science is actually really difficult. It’s complex because it’s current. One of the things that we have developed, and actually have a good model for is rapid turnaround for current science spaces.”

Staff at the Science Museum of Minnesota talked about solving the problem of time and money within their exhibits that present current science. One participant said, “We built a library of furniture so that we could reuse it over again. We still struggled with the turnaround time that it took to get stuff out on the exhibit floor...” Their web platform, *Science Buzz*, allowed the Museum, “to publish content to the exhibit floor from anywhere.”

c) *Programs led by staff*

Participants discussed programs that were led by staff. The Museum of Science, Boston talked about visitor participation in live presentations and exhibit spaces as ways to allow people to interact with current science. One interviewee called the presentations a “showcase” and the space a “playground.”

Koshland talked about how they always strive to be as interactive as possible, in both their exhibits and even more in their programs. Interactivity was used as a method to explain science concepts. One participant said, “We try to use hands-on science activities to break down things that can be hard to understand if you’re a student.” Many of these interactions are with volunteers and staff present on the floor, aside from volunteer scientists.

The participant from the Museum of Life and Science talked about the challenges of having museum educators present current science to visitors. The challenge came from the educators not having a personal connection to the research. The Museum incorporated training in improv to allow for these conversations to be organic. The interviewee said:

Conversation, you never know where it's going. You never know an answer and adult or a kid might give you when you ask questions that are so open-ended that you never know where it's going to go and improv really helps you think on your feet and how to best deal with those types of situations.

The Pacific Science Center mentioned an interest in incorporating more discussion with facilitators on their floor. One interviewee said, "One of the ways we see talking about current science is literally talking about it, so having more facilitators that can engage with visitors at all points on campus."

d) Encourage bi-directional nature of science learning and understanding

Participants talked extensively about the importance of methods that allow for the bi-directional nature of science learning and understanding. Science Central talked about interactivity in relation to their exhibits. The interviewee said, "How we would present information, whether it's current science or non-current science, we have hands-on, interactive exhibits where visitors would be able to have an experience." The Science Museum of Minnesota talked about specific interactive activities on the floor. Some examples were a quiz show that allowed visitors to answer questions and compete each other and a newscast where visitors would read allowed current science news stories, the benefit was reading stories aloud helped visitors retain information. One participant said, "These are really engaging activities that deliver the same kind of information just in a really fun way."

The Museum of Science, Boston and the Science Museum of Minnesota talked about forums within their institutions. For the Museum of Science, forums allowed people within the community to discuss the implications of scientific research in their community. One staff member said, "we realize those [new science and technologies] have societal implications in the world that we make decisions about those things" he said they help them "figure out how emerging technologies play out in society." The Science Museum of Minnesota talked about

including forums in conjunction with some to exhibits they have. An example of a forum they hosted was one that was related to an exhibition on early childhood development. The topic of the forum was on who can make what decisions on early childhood development (parents, scientists, elected officials, etc.). Forums like these are “a way of taking some of that science in those exhibits and thinking about what social issues were related to those,” stated one participant.

Participants raised several challenges that they felt affect their methods, particularly those that deal with the bi-directional nature of science. Audience was one such challenge. Morehead talked about making content accessible to all ages. One presenter said, “Presenting the science in a way that’s age appropriate” is a challenge. Science Central talked about how they were looking to expand their audiences. The participant said, “Whether it’s existing audiences that we already work with or brand new audiences...by that I mean a group within the community that maybe we haven’t worked with before.” The challenge with audiences for the Pacific Science Center, the Science Museum of Minnesota, and Museum of Science, Boston was attracting audiences that have an interest in science. The Pacific Science Center is working on how to attract those audiences. One participant called those audiences “science inattentive people.” He said the Pacific Science Center tends to, “attract very science attentive individuals, they come here because they’re interested in science. They would go to a ball game. How do we find ways to attract science inattentive people?”

The Science Museum of Minnesota talked about how there are topics the museum feels are important, NSF [National Science Foundation] feels are important, but visitors may not, “necessarily mean the public thinks they’re interested in it.” The problem that comes up is how to solve this issue? The Museum of Science addressed the challenge of attracting audiences that

aren't exactly looking for current science topics. A solution stated by a participant member was, "rather than going deep, deep, deep into the science, we want to focus on 'So what?'"

Another challenge facing some participating sites is the complexity of the topic. For Koshland, "The most challenging thing, from a programming point of view, is how to make something like climate change and try to make it fun and interesting" said a participant. To overcome this challenge, Koshland staff added interactivity to their programs, as well as exhibits, to alleviate some of the issues with the "gloom and doom" of some topics like climate change. The Museum of Science, Boston also faced this challenges and tried to solve it within their Current Science and Technology Department. One staff member said they work with researchers to, "find out what the sweet spot is between the very specific research that is funded by this grant funder, compared to how the public is going to internalize it is a challenge and a challenge worth doing." They work to make content that is translatable to any visitor in the Museum. Aside from the challenge of presenting current science to all ages, the Pacific Science Center also faced the challenge of presenting current science in a holistic way. Some topics are complex, and some research is done by various scientists. One staff member said, "We want to present current science in a holistic way, there's not just one entity working on cancer, there's a lot of entities that's working on cancer." She said the problem can arise when one funder wants to present one point of view for research, while the Pacific Science Center may need that money they also want to present all points of view for the research. Finding other sources of funding was one way to alleviate this challenge.

Research Question 3: Visitor outcomes with current science

Finally, participants were asked about their goals for visitor engagement with current science. Two key themes emerged: a) participating institutions want their visitors to understand the nature of science, including the process of how science is done, science content, and the implications of new scientific research and technologies; and b) they want their visitors to be more engaged with science, either through interest, pursue future careers, or as decision makers for new policies and funding options for scientific research.

a) *Understand nature of science*

Participants discussed how they wanted visitors to understand the process of scientific research. Participants from Morehead related this goal to their place on a university campus. One participant said, “I think there’s something about Morehead providing a window into the way academic research happens and the process...” Morehead staff interact daily with researchers on campus and even invite academic researchers to talk with visitors.

The Museum of Science, Boston discussed their goals for showing people what science can do and what science needs to do to allow for new research and technologies. One participant said they want they were aiming for, “informing the public. How does science work? How does it happen? How is it funded? How does it progress? There are challenges and hurdles and things that come along the way.”

One participant from the Pacific Science Center said he hoped that visitors have an appreciation for “how scientists go about doing their work.” He also said one of the main goals behind the founding of *Portal to the Public* was to allow for visitors to science centers and science museums to understand how scientists go about doing their work. Another staff member from the Pacific Science Center spoke to visitors understanding the process of science through

their exhibits. She said she wanted visitors to understand, “That we find new information every single day and that gets applied and our models change or they don’t. It’s not a static thing.”

Participants from the Pacific Science Center and Science Central talked about their goals in having visitors understand science content. One participant from the Pacific Science Center talked about visitors appreciating science content. He said, “We certainly hope that they’ll have a better appreciation for not only science content, but more about how scientists go about doing their work.” The interviewee from Science Central hoped that people would leave understanding “facts and figures” and went on to say he wanted them to “make connections between those facts and figures and their lives.” Both participants spoke to the idea of taking content and facts learned at their institutions and connecting them to a bigger part of understanding science, who scientists are, what they do, and how science affects the lives of all people.

Many participants discussed their goals for having people understand how science can have implications for their lives. The participant from the Museum of Life and Science referred back to their goals of including more conversations in the work they do with NISE Net and on the Museum floor. He said, “We thought early on that conversations were a good way to go about talking about some of the issues we faced around current science and technology and whether or not there are some ethical implications, economical implications.” He also spoke about how educators and scientists on their floor can help bring about deeper conversations around the impact of science:

They’re encouraging visitors to share their values and talk about how these may be relevant to their lives and how they may be relevant to people in other countries, or how they may help solve problems for other people, and may even be used for nefarious reasons in other areas.

Participants from the Museum of Science, Boston talked a lot about their work with dialogue in programs and exhibits and how this can help accomplish their goal of helping visitors

understand the implications of scientific research. One participant discussed their goals for their provocative questions exhibition: “We have a provocative questions exhibition which takes a socio-scientific topic where people can discuss the societal and ethical implications around questions and create an argument around that through conversation.” He talked about how through this and other initiatives the museum does, they want visitors to understand that science plays a role in our society and the things the people are doing for scientific research are worthwhile. The participant further confirmed this goal. He said he hoped “people think about policies that affect their community and their world.”

b) More engaged with science

All participants talked about their goals for greater public engagement with science, particularly with their visitors becoming more active and interested in science. Participants from the Koshland referred to the mission of their museum when talking about being more active in science. One participant said, “They get something related to the mission of the museum, which is to help people use science to solve problems in their own communities.” Morehead staff talked about general engagement that can lead to future involvement. One participant said they want their visitors to have “an interest and engagement with science in general so that they can get excited about what’s happening with science and maybe go home, or go to their classroom and get more involved with it.” The interviewee from the Museum of Life and Science talked about visitors being more engaged with science after their visit to the Museum:

We can start asking questions that we don’t know the answer to, but we hope our visitors will begin to think about when they start to learn about other technologies, when they read the newspaper, or when they turn on the TV and on the nightly news they see some new current science and maybe they apply the same questions.

Staff at the Museum of Science, Boston talked about the future of their institution and how they want to present current science. One staff member said, “I think there’s going to be a more active role in having people think about themselves shaping the future of science.” They hope to do this through future dialogue and other conversations that can occur within their museum. One staff member at the Pacific Science Center talked about his hope for “developing an enthusiasm, an identity with science.” Another staff member talked about developing a “sense of pride” in the scientific research that is happening in visitors’ community. The participant from Science Central talked about the choices people will make when thinking about science in their lives. He gave hypothetical examples. He said he wanted people to say things like, “I’m gonna watch a science show on TV instead of a sporting event. I will read this science article rather than the stock market magazine.” Finally, the Science Museum of Minnesota talked about how people can think of themselves as scientists. One participant said, “You’re maybe more of a scientist than you think. Maybe you care about this in ways that you didn’t think you did, maybe it’s just interesting.”

A few participating institutions talked about visitors choosing a future career in a science-related field. Staff from Morehead and Science Central spoke to this in terms of how they want people to see science in general. A participant from Morehead said they want visitors to “Think about it as a career and really see that science is expanding and it’s happening around us.” The participant from Science central said, “I would like for them to walk out of here saying, ‘Science is fun. I can become a scientist when I grow up.’”

Participants at The Museum of Science, Boston talked about how many scientists who participate in their programs and talk with the public hope to inspire people to become scientists. Staff from the Museum of Science talked about how, while it is a great goal, it will not always

happen. One participant said, “I think when we talk more with them they understand that there’s value to just informing the public about science in general, beyond just inspiring the next generation.”

Finally, there’s the goal for participating institutions to have visitors make informed decisions about science that affects their lives. For example, one participant from Koshland said she wants people to “learn something that encourages them to take some sort of action when they leave.” One participant from the Science Museum of Minnesota talked about science as “an essential literacy.” She said this literacy is important because “people are asked to make decisions that, in theory should be based on scientific evidence, all the time.” The participant from the Museum of Life and Science discussed the efforts of the Museum and NISE Net changing the way people view scientists and science and how this can help people feel more confident in making choices for policies and funding for technologies. He said that this understanding of science will help people understand “the public should and can play a role in whether or not these technologies are adopted.”

Staff from the Pacific Science Center talked about how people can interact with emerging scientific research in their lives. One participant said she hoped “When they do see these things in the headlines and when certain things do come up that have become politicized, that they are just better informed, and maybe even willing to do a little of their own unbiased research.” Staff at the Museum of Science, Boston discussed the roles that people can play through the decision they make about science. One participant talked about how forums can help people understand the role they have in science. He said science and technology have implications and “we make decisions about those things as funders, decision makers, as consumers, as parents, as teachers, as politicians, to figure out how technologies play out in society.” Having this informed citizenry

can make the decision that can impact us. This is further indicated by a participant who said, “Science doesn’t make the decision, science informs the decision and the decision comes from all of the stuff that you bring as a consumer and parent.”

CHAPTER 5: Conclusions and Implications

The purpose of this study was to examine how museums and science centers define and present current science to visitors. Semi-structured interviews were conducted with 11 staff at seven institutions, asking them how they think about current science, the methods they use to present current science to the public, and what they want their visitors to get out of their experiences with current science.

Conclusions

Findings suggest no formal definition of current science amongst most of the participating institutions, yet there is a variety of different ways they think about current science. All but one participating institution did not have a formal definition for current science, however, all other sites do think about how they may go about providing a definition for current science. Some references to current science include context-specific conversations within their respective institutions, made references to STEM (science, technology, engineering, and math), and talked about how obviously it is about new and emerging research on science in technology. What is interesting is how it is generally not a clear, written information. There could be various reasons for why this is. Current science is always changing and institutions are working to keep up with science to present in their museums, and they may not feel that there is a need to specifically define current science. It is something that is talked about within their institutions, and the research feels that if they were asked to write down a formal definition of current science, every individual institution would be able to do so. The literature suggests a definition of current science, which is generally considered unfinished, or ongoing research with ongoing debates of the validity of the research within the scientific community (Durant, 2004; Hine & Medvecky,

2015). Much of what is mentioned by these institutions fits into this view. This study also suggests a balance between presenting current and established science.

When thinking about current science, this study suggests participating institutions use various sources of information to find current science content. One way participating institutions do this is through their work with researchers and research sites. Other sources of information are media and publications, such as journals, popular magazines, and social media, to name a few. Institutions look to their own visitors and staff. The literature did not suggest ways institutions that present current science look for information, and so these results fill a gap in terms of clarifying how museum professionals find relevant information about current science.

For interpretive methods related to presenting current science, institutions want their visitors to have face-to-face contact with scientists. The benefits of visitors interacting with scientists, and vice versa, have been discussed in the literature (Allum, 2010; Chittenden, 2011; Guston, 2014; Selvakumar & Shugart, 2015; The American Association for the Advancement of Science, n.d.). *Portal to the Public* is a model that supports this by supporting and encouraging scientists to work with the public. The benefits of having visitors interact with scientists include a greater understanding and interest in science (Angie Ong, 2014; Dennis Schatz & Lauren Russell, 2010; Selvakumar & Storksdieck, 2013). These benefits, such as a greater appreciation and understanding for science can occur through conversations and discussions with scientists. Visitors can connect with scientists because scientists learn how to personalize conversations. One benefit suggested by this study was the chance for visitors to understand what exactly a scientist is, who they are, and what they do. Informal science education institutions can collaborate with scientists to share ideas, resources, and skills for science communication.

Participating institutions want their exhibits to be rapid changing. Sometimes this can involve exhibits with furniture that can be quickly changed, easy to change spaces. One thing participants think about is to ensure exhibits are interactive. The literature refers to the benefits of having interactive activities, “active learners are viewed as experts in their own right, whose experience is recognized as a valid way of knowing” (Yaneva et al., 2009, pp. 79–80).

Interactivity also allows for visitors to participate in dialogue surrounding the implications of current research and technology. This finding confirms what Bell (2009) argued in the literature, museums can help the public be involved with science by “becoming forums for dialogue and debate” (Bell, 2009, p. 25).

This study also suggests the participating sites use methods that allow for staff to interact with the public. Some of the challenges are that staff does not have the personal connection to the topic and this can affect how the visitor makes a connection to the topic. One way to bypass this challenge is to consider training staff in being able to have conversations where they can think on their feet.

Participants discussed methods that allow for the bi-directional nature of learning and understanding. Audiences are not necessarily looking for these topics related to current science, and many do not have an interest in science. Part of the challenge is figuring out how to get those audiences interested in science before getting them interested in current science research. A challenge facing study participants is translating the complexity of the topic. There are some science topics that require extensive explanation and museums and science centers can only provide so much information to visitors. Part of the solution is deciding how to talk about topics: using interactive activities, talking about the implications of research and the importance of

research to everyday life. These challenges facing science museums and science centers are confirmed in the literature (Chittenden, 2011; Guston, 2014; Sanchez-Mora, 2014).

This research suggests that participating institutions want their visitors to understand the nature of science through their interactions with current science. Study participants want visitors to understand the process of science: it is not easy and is always changing. Some participants feel that visitor understanding science content is important, but must relate that content to their lives and how science can affect them. Lastly, study participants want visitors to understand the general implications of science research. In the literature, Allum (2010) refers to the importance of museums and science centers providing the “ability to citizens to read about, comprehend, and express opinions about science” (p. 725).

Finally, this study found that participating institutions want their visitors to be more engaged with science upon leaving their respective institutions. In the literature, studies suggest that visitors can better understand their role in society through further engagement in science (Kuslansky & Peduto, 2013). The results of this study suggest participating museums share the same goals for public engagement with science. Participants discussed their goals for visitors becoming more engaged with science: they will go home and read more articles, participate in conversations on new research, and become more excited for scientific research. Some participants talked about the hope that some visitors will be inspired to pursue careers in science. Lastly, participating institutions expressed their hope that visitors will make informed decisions in relation to emerging science and policies related to science research and funding related decisions. The Association of Science-Technology Centers (2013) also shares this goal, “Science centers and museums are preparing a new generation of responsible global citizens who will be able to address the problems that will face our world over the next century” (p. 8).

Implications

For practitioners, this research suggests possible approaches, resources, and ideas for those who want to address current science within their institutions. One of the most important things suggested by this research is for practitioners to think about how their institution views current science. This research suggests potential sources of information from where to pull current science content as well as examples of how science museums and science centers that participated in this study view current science. This research suggests science museums and science centers think about future collaborations with researchers in their area and to build relationships with those researchers and their respective institutions. Practitioners should think about the potential challenges involved with presenting current science, including the audiences they serve, the topics they want to talk about, and the resources available to them. Finally, practitioners should think about their goals for visitor engagement with current science.

Researchers can use this study to see evidence of how science museums and science centers view current science. Only seven institutions were studied and only provide a glimpse into what else may be happening in the field. However, these seven institutions can serve as an example for studying the methods for presenting current science and the outcomes of those methods. Researchers can get an idea of what institutions want their visitors to understand about current science and can provide a background for future study.

This study opens up opportunities for future research in this area. This study looked at seven institutions that present current science; future studies can look at a survey of more science museums and science and talk to more employees at those institutions. Future studies can also look at how other informal science education institutions present current science, such as aquariums, zoos, botanical gardens, natural history museums, etc. It would be interesting to talk

to floor staff who interact with visitors, including volunteers and educators who work mostly on the floor (not so much in the back of house). Past studies have been conducted on what visitors and scientists get out of their interactions with each other. One final interesting study would be to assess how scientists view current science in relation to presenting it to visitors, and to study how visitors view current science before and after their visit to informal science education institutions. A greater understanding by museums and science centers of how all stakeholders to museums and science centers view current science

References

- Allum, N. (2010). Science Literacy. In S. Priest (Ed.), *Encyclopedia of Science and Technology Communication* (pp. 725–727). Thousand Oaks: SAGE Publications, Inc. Retrieved from <http://sk.sagepub.co.m.offcampus.lib.washington.edu/reference/scienceandtechnology/n246.xml>.
- American Alliance of Museums. (n.d.). STEM Education. American Alliance of Museums. Retrieved from <http://www.aam-us.org/docs/default-source/advocacy/brief-nsf>.
- Angie Ong. (2014). *Summative Evaluation Report: Portal to the Public Network*. Retrieved from http://popnet.pacificsciencecenter.org/images/publications/IMLSPoPNet-Summative-Evaluation-Report_FINALCompiled.
- Association of Science-Technology Centers. (2013). Advancing Science and STEM Learning... The Future Depends on it. Retrieved February 10, 2016, from http://www.astc.org/wp-content/uploads/2014/10/2013_Case_for_Support.
- Barry, S. (2014a, June). Are you Q?rius? *Dimensions*, 7.
- Barry, S. (2014b, June). New Showcase for California's Biodiversity. *Dimensions*, 9.
- Bell, L. (2009). Engaging the public in public policy. *Museums & Social Issues*, 4(1), 21–36.
- Chittenden, D. (2011). Commentary: Roles, opportunities, and challenges—science museums engaging the public in emerging science and technology. *Journal of Nanoparticle Research*, 13(4), 1549–1556.
- Clough, G. W. (2011). *Increasing Scientific Literacy: A Shared Responsibility*. Smithsonian Institution.
- Cohen, J., & Macfarlane, H. (2007). Beer and bosons at the Café Scientifique. *Museums & Social Issues*, 2(2), 233–242.

- Dean, D. (2001). *Museum Exhibition: Theory and Practice*. London: Routledge.
- Dennis Schatz, & Lauren Russell. (2010). *The Path Forward: Lessons Learned and Recommendations from the Portal to the Public Second Synthesis Meeting*. Pacific Science Center. Retrieved from <http://popnet.pacificsciencecenter.org/images/publications/synthesis2>.
- Department for Innovation, Universities & Skills. (2008). *A Vision for Science and Society*. United Kingdom: Department for Innovation, Universities & Skills. Retrieved from <http://webarchive.nationalarchives.gov.uk/20120708131021//>.
- Durant, J. (1992). *Museums and the Public Understanding of Science*.
- Durant, J. (2004). The Challenge and Opportunity of Presenting “Unfinished Science.” In *Creating Connections: Museums and the Public Understanding of Current Research* (pp. 47–60). Walnut Creek, CA: AltaMira Press.
- Feder, M. A., Shouse, A. W., Lewenstein, B., Bell, P., & others. (2009). *Learning science in informal environments: people, places, and pursuits*. Washington, D.C: National Academies Press.
- Feinstein, N. W., & Meshoulam, D. (2014). Science for what public? Addressing equity in American science museums and science centers. *Journal of Research in Science Teaching*, 51(3), 368–394.
- Gupta, N., Biswas, N., Mondal, N. K., Rautela, G. S., Emdadul, I., & Hoyt, M. (2014, June). Testing the Waters: Students in India Monitor Arsenic Levels. *Dimensions*, 44–45.
- Guston, D. H. (2014). Building the capacity for public engagement with science in the United States. *Public Understanding of Science*, 23(1), 53–59.
- Haywood, B. K., & Besley, J. C. (2014). Education, outreach, and inclusive engagement:

- Towards integrated indicators of successful program outcomes in participatory science. *Public Understanding of Science*, 23(1), 92–106.
- Hilton, M. (2015). Preparing Students for Life and Work. *Issues in Science and Technology*, 31(4). Retrieved from <http://issues.org/31-4/preparing-students-for-life-and-work/>.
- Hine, A., & Medvecky, F. (2015). Unfinished Science in Museums: a push for critical science literacy. *Journal of Science Communication*, 14(2), 1–14.
- Institutue of Museum and Library Services. (n.d.). Museums, Libraries, and 21st Century Skills: Definitions | Institute of Museum and Library Services. Retrieved February 9, 2016, from <https://www.imls.gov/impact-imls/national-initiatives/museums-libraries-and-21st-century-skills/museums-libraries-and-21st-century-skills-definitions>.
- Jha, A. (2008). Greatest technological challenges facing humanity. Retrieved May 24, 2016, from <http://www.theguardian.com/science/2008/feb/15/technological.challenges>.
- Kuslansky, E., & Peduto, G. (2013, October). Reimagined and Rebranded: Science Centers for the 21st Century, 31–33.
- Leshner, A. I. (2003). Editorial: Public Engagement with Science. *Science*, 299(5609). Retrieved from <http://www.jstor.org/offcampus.lib.washington.edu/stable/pdf/3833513.pdf?acceptTC=true>.
- Lowhater, T. (2009). Science in the Obama Administration. *Museums & Social Issues*, 4(1), 15–20.
- National Aeronautics and Space Administration. (2016, February 11). What is science? :: NASA Space Place. Retrieved February 12, 2016, from <http://spaceplace.nasa.gov/science/en/>.
- National Science Board. (2016). *Science & Engineering Indicators 2016* (pp. 1–5).

- National Science Foundation. (2014, March). NSF Strategic Plan for 2014-2018. National Science Foundation. Retrieved from <http://www.nsf.gov/pubs/2014/nsf14043/nsf14043>.
- Obama, B. (2009). Address by Barack Obama, 2009 | Inauguration of the President. Retrieved February 11, 2016, from <http://www.inaugural.senate.gov/swearing-in/address/address-by-barack-obama-2009>.
- Priest, S. (2013). Critical Science Literacy What Citizens and Journalists Need to Know to Make Sense of Science. *Bulletin of Science, Technology & Society*, 33(5-6), 138–145.
- Raloff, J. (2010). Don't Know Much about...: A Measure of U.S. Science Literacy Has Increased - to 28%. *Science News*, 177(6), 13.
- Rutherford, F. J., & Ahlgren, A. (1990). *Science for All Americans*. Oxford University Press. Retrieved from <http://www.project2061.org/publications/sfaa/online/chap1.htm?txtRef=http%3A%2F%2Fwww%2Eaaas%2Eorg%2Fsearch%2Fgss%2Fcurrent%2520science&txtURIId=%2Ftools%2Fsfaaol%2Fchap1%2Ehtm>.
- Sanchez-Mora, M. C. (2014). Evolution of evaluation in science museums and centres. *JCOM*, 1, C02.
- Selvakumar, M., & Shugart, E. (2015). Key Insights from Museum Studies. Retrieved from <http://www.academyhealth.org/files/FileDownloads/LessonsProjectMuseumStudies>.
- Selvakumar, M., & Storksdieck, M. (2013). Portal to the Public: Museum Educators Collaborating with Scientists to Engage Museum Visitors with Current Science. *Curator: The Museum Journal*, 56(1), 69–78. <http://doi.org/10.1111/cura.12007>.
- The American Association for the Advancement of Science. (2016, January). Mission & History of AAAS. Retrieved February 12, 2016, from <http://www.aaas.org/about/mission-and->

history.

The American Association for the Advancement of Science. (n.d.). Why Public Engagement Matters. Retrieved February 9, 2016, from <http://www.aaas.org/pes/what-public-engagement>.

US EPA, C. C. D. (2010). U.S. and Global Temperature [Reports & Assessments,]. Retrieved May 24, 2016, from <https://www3.epa.gov/climatechange/science/indicators/weather-climate/temperature.html>.

U.S. Global Change Research Program. (2014). *Climate change impacts in the United States: U.S. national climate assessment*. Retrieved from <http://purl.fdlp.gov/GPO/gpo48682>.

van Est, R. (2011). The Broad Challenge of Public Engagement in Science. *Science Engineering Ethics*.

Vannevar, B. (1945). *Science the Endless Frontier* (p. 35). Office of Scientific Research and Development. Retrieved from <http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm>.

Whitehouse, J., Waller, B. M., Chanvin, M., Wallace, E. K., Schel, A. M., Peirce, K., ...

Slocombe, K. (2014). Evaluation of Public Engagement Activities to Promote Science in a Zoo Environment. *PLoS ONE*, 9(11), e113395.

World Health Organization. (2014). Cancer Fact Sheet. Retrieved May 24, 2016, from <http://www.who.int/mediacentre/factsheets/fs297/en/>.

Xie, Y. (2014). Is U.S. Science in Decline? *Issues in Science and Technology*, 30(3). Retrieved from http://issues.org/30-3/yu_xie/.

Yaneva, A., Rabesandratana, T. M., & Greiner, B. (2009). Staging scientific controversies: a gallery test on science museums' interactivity. *Public Understanding of Science*, 18(1), 79–90.

Zerhouni, E. (2008). From the NIH Director: The Value of Medical Research. *NIH Medicine Plus*, 3(3), 2–3.

Appendices

Appendix A: Interview Guide

Interview Guide

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Phone: 206.685.3496 // Email: jjluke@uw.edu

Consent Script

I am asking you to participate in an interview that is part of my Master's Thesis work at the University of Washington. The purpose of this study is to examine how science museums and science centers define and present current science to public audiences.

Your participation is voluntary. Refusal to participate will involve no penalty or loss of benefits, and you may discontinue participation at any time. This interview will be recorded. However, your responses will be confidential. Your name will not be identified and while I may quote you, that quote will not be attributed to you. If you have any questions now or in the future, you may contact me or my Thesis Committee Chair using the contact information I shared with you.

Do you have any questions? Do you agree to participate in this interview?

Interview Questions

My first set of questions ask about your definition of current science:

1. How do you define current science? How do you define established science? Have you had a chance to discuss this definition with colleagues within your institution, are there differences and similarities between definitions?
2. How did you determine your definition of current science? What contributed to your current definition?
3. How does your institution stay up to date with current science? Do you have any resources that you use to stay abreast with current science?

My next set of questions ask about your institution's interpretive methods in presenting current science:

4. I understand that your institution uses a range of interpretive methods in presenting current science. What went into thinking about choosing those interpretive methods? Why do you use those interpretive methods over others?
5. What are your institution's biggest successes in presenting current science? Why were they successful?
6. What are the main challenges or restrictions your institution faces when presenting current science? How have you/might you go about addressing those challenges or restrictions?

My next set of questions ask about your institution's goals in visitor engagement with current science:

7. What audiences do you consider when designing or adapting interpretive methods for presenting current science? How did you determine these were the audiences you want to reach out to?
8. What do you hope your visitors get out of these experiences with current science?
9. Have you conducted any evaluation studies that assess visitor experiences with current science? What were the results of those studies?

I have one last question to ask you.

10. What do you see as the future of interpreting current science within your institution?

Prompts: Are there trends in current science that you want to address? Things you hope to implement? Audience reactions to STEM and Public Engagement with Science?

Appendix B: Data Analysis Coding Matrix

| Research Question | Theme | Sub-theme | Museum/Science Center | Quote/Example | | |
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| Question 1 | | | | | | |
| How do science museums define current science? | 1. Variety of Definitions | A. Thinking about current science | Koshland | “Since our museum is part of the National Academy of Sciences, they have a lot of standards, not formally written, but the NAS considers itself a body that produces scientific opinions and information that is based on published and reviewed scientific information.” | | |
| | 1. Variety of Definitions | A. Thinking about current science | Morehead | “We actually have an organizational definition. We talk about this somewhat regularly. We think of current science as related to the frontiers of science research as well as today’s events and issues.” | “We have a working group that overtime developed the definition and we had a staff discussion about it to ratify it and make sure we were on the right track. Over a period of several months we came with the working definition.” | |

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| | 1. Variety of Definitions | A. Thinking about current science | Museum of Life and Science | “I do have conversations with colleagues at the museum, but it’s very rare I go in about once a month.” | “Nanotechnology... We knew that it was going to be an issue of something that museums hadn’t really faced in the past.” | |
| | 1. Variety of Definitions | A. Thinking about current science | Museum of Science | “I don’t know that we have a specific operating definition within the group or anything like that, but what we would consider to be current science would be science related to research that is currently happening or very recently published and relevant and interesting for members of the public in general for any number of reasons.” | “Something the museum never did a lot of before, but is a huge part of our work now is engineering...that is certainly an area of science that is very high priority at the museum.” | |
| | 1. Variety of Definitions | A. Thinking about current science | Pacific Science Center | “It goes beyond science, technology, and engineering. It goes to STEM. I think it also goes to applications. What people are doing in the health field, technologies, or radiation treatments.” | “We talk about it everyday. Science centers everywhere right now are figuring out how to be relevant to their communities. We also live in a really interesting time in human history. We have some big problems that we’re facing, and science | |

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| | | | | | and all that's represented in science is a key piece of how we figure out how to navigate some of these big problems that we have." | |
| | 1. Variety of Definitions | A. Thinking about current science | Science Central | "I think it's self-explanatory. I think that current science is the scientific, research, breakthroughs, technology that is being presented to both scientists and or the general public." | | |
| | 1. Variety of Definitions | A. Thinking about current science | Science Museum of Minnesota | "Obviously science is always a work in progress, right?" | "Being able to get a definition out there that visitors could relate to...we needed this really flexible definite, that still and these clear buckets that stories could fit into." | |
| | 1. Variety of Definitions | B. Balance between current and established science | Museum of Life and Science | "Established science is really anything we've known to be true for years. And this is something that museums typically cover more, in fact probably quite a large percentage of | | |

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| | | | | museum exhibits and programs deal with established science, the things that we've known to be true for years." | | |
| | 1. Variety of Definitions | B. Balance between current and established science | Science Central | "How we would present information, whether it's current science or non-current science, we have hands-on interactive exhibits where visitors would be able to have an experience by manipulating the exhibit and having a part of or touching the exhibit." | | |
| | 1. Variety of Definitions | B. Balance between current and established science | Science Museum of Minnesota | "We ended up often times trying to piggy back current science stories. Things that were emerging, things that were still hot and being tested. So we're really top of mind." | | |
| | 2. Pull from various sources | A. From home institution | Koshland | "My background...having gotten an undergraduate degree in science. Having exposure to science in my undergraduate studies." | | |
| | 2. Pull from various sources | A. From home institution | Museum of Life and Science | "It's a culmination of ten years of working in the field of nanotechnology education that helped me shape my understanding of | | |

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| | | | | what current science is.” | | |
| | 2.Pull from various sources | A. From home institution | Museum of Science | “I would say that that’s kind of how the people I worked with considered it when I joined the museum. It has to do with how the museum was already thinking about it.” | | |
| | 2.Pull from various sources | A. From home institution | Pacific Science Center | “I’m a research astrophysicist by training, so I come from current science.” | | |
| | 2.Pull from various sources | B. Researchers /Research Sites | Koshland | “All of our exhibits are based upon information that has come from NAS reports.” | | |
| | 2.Pull from various sources | B. Researchers /Research Sites | Morehead | “We’re daily interacting with researchers who are doing current scientific research.” | “We also use some of the resources the university produces.” | |
| | 2.Pull from various sources | B. Researchers /Research Sites | Museum of Life and Science | “Looking at stuff that’s still in the lab being research and worked on and I think that for museums we look at that type of information where there really aren’t a lot of knowns, there’s still a lot of unknowns and the museum’s goal, I think is to try to bring some of that out.” | “I spent a lot of time reaching out to scientists in the area and trying to get them to understand what the museum is and how we’re trying to incorporate more current science into our programming efforts.” | |

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| | 2.Pull from various sources | B. Researchers /Research Sites | Museum of Science | “Research that’s happening in labs and if it connects to things that people want to know about and are interested in.” | | |
| | 2.Pull from various sources | B. Researchers /Research Sites | Pacific Science Center | “We essentially pull from the research community to inform the public.” | “Typically we would identify the exhibit topic or program topic, and then we would find the expertise to help develop that program.” | “No one institution can be an expert in all areas of science.” |
| | 2.Pull from various sources | B. Researchers /Research Sites | Science Central | “We have a very strong, and close connection to NOAA and NASA.” | | |
| | 2.Pull from various sources | B. Researchers /Research Sites | Science Museum of Minnesota | “We had lots, and lots, and lots of partnerships with academics all over the country, but especially here in Minnesota.” | | |
| | 2.Pull from various sources | C. Media and publications | Morehead | “We all read professional journals and popular publications.” | | |
| | 2.Pull from various sources | C. Media and publications | Museum of Science | “We have this general guideline that if you could find a paper or news article that talked about the topic you were covering from the last six months we consider that currentish.” | | |

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| | 2.Pull from various sources | C. Media and publications | Museum of Life and Science | “I also am part of several listservs online.” | “We have a couple people who scour news sources and articles.” Twitter and Facebook, “follow the right people.” | |
| | 2.Pull from various sources | C. Media and publications | Pacific Science Centers | “Whatever that is, whatever the headline or breaking news is.” | “It’s been true with almost every current science exhibit that we’ve done is headline news.” | |
| | 2.Pull from various sources | C. Media and publications | Science Museum of Minnesota | “We relied on plenty of stuff like <i>Nature</i> , and <i>Science</i> , and the American Museum of Natural History used to run this program called <i>Bulletins</i> , which was current science from their perspective.” | | |
| | 2.Pull from various sources | D. Public | Science Museum of Minnesota | “We have so much user generated content.” | “We were running part of our program off of a web platform, we could just see what people were searching for.” | |
| Question 2 | | | | | | |

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| What methods are science museums using to present current science to the public? | 1.Face-to-face interactions | | Museum of Life and Science | “I think it’s also important for the public to meet those people. And maybe they relate to them, because that scientist is a person of color or is a female, and inspire new people who may not feel they have an opportunity in the sciences.” | “Scientists begin asking questions of the public instead of just disseminating their research.” | “Scientists will start asking questions of the public, and then hopefully using some of those answers and some of those conversations to maybe direct their further investigations or research.” |
| | 1.Face-to-face interactions | | Museum of Science | “We have volunteer interpreters who are scientists on the floor, rather than being brought in as guests, sometimes you have a retiree who is 73 years’ old who used to work in a lab, comes in every Saturday and does DNA extraction, but puts her spin on it. There’s that personal connection to it.” | (In relation to using visitors as data) “it’s required that these people actually translate their science for the public and so that’s a very different way of doing current research but it’s actually expanding in terms of scope here.” | “And a lot of special events focus on getting researchers to interface directly with the public...getting visitors to interface directly is a huge success.” |
| | 1.Face-to-face interactions | | Pacific Science Center | “People really appreciate that you’re talking to a real scientist.” | “Scientists feel empowered. They feel they can explain their work. And for some of them, it’s their first time they’ve been | |

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| | | | | | able to explain their work.” | |
| | 1.Face-to-face interactions | | Science Central | “How to take their research and explain it in a way that a family or school group would understand.” | | |
| | 1.Face-to-face interactions | | Koshland | “They do have an expert, or at least a voice of authority which really does lend itself to making that experience all the more authentic. These students, young adults, adult, that are coming to the programs, they end up getting to see real life scientists that are working in STEM careers and I think that is something that is really unique to our programs.” | | |
| | 1.Face-to-face interactions | | Museum of Life and Science | “We break down the stereotype of who and what a scientist is and how the public should and can play a role in whether or not these technologies are adopted.” | | |

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| | 1.Face-to-face interactions | | Pacific Science Center | <p>“One thing we really thought was for people to understand that scientists are, to a large extent, like everyone else...it humanizes the nature of science and the nature of people who do science.”</p> | <p>“We now have the Living Lab. We have researchers that do human subject research. They are not only using science center visitors for their research at the UW, it’s also an interpretive process. As part of them doing science, you learn more about the process of science.”</p> | |
| | 1.Face-to-face interactions | | Morehead | <p>“We’re actually in the beginning stages of a renovation of our building and part of that is to create a current science exhibit gallery. Where we’re going to be directly addressing current science that is being done by researchers at UNC.”</p> | | |
| | 1.Face-to-face interactions | | Museum of Life and Science | <p>“The only way that we can be truly effective at delivering current science is to bring the scientist to the museum and have them help us facilitate these activities.”</p> | | |

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| | 1.Face-to-face interactions | | Museum of Science | “One of our main resources is the significant partnerships we form with these NSF funded research centers.” | | |
| | 2.Rapid Change Exhibits | | Pacific Science Center | “Is there a way for us to deliver current science that’s not a video, that is as nimble as our 500 sqft spaces, but perhaps with only one interactive? I don’t have those answers because we’re figuring that out right now.” | | |
| | 2.Rapid Change Exhibits | | Science Central | “How we would present information, whether it’s current science or non-current science, we have hands-on interactive exhibits where visitors would be able to have an experience by manipulating the exhibit and having a part of or touching the exhibit.” | | |
| | 2.Rapid Change Exhibits | | Science Museum of Minnesota | “One was a quiz show that we could update from the web. We could make sets of questions where visitors could compete against each other.” | “We had a newscast...reading news stories was pretty wildly popular. People retained things they read out loud too. It was a really nice | “These are really engaging activities that still deliver the same kind of information just in a really fun way.” |

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| | | | | | innovation that worked well.” | |
| | 2. Rapid change exhibits | | Morehead | “We do a lot with programs because the ability to turn a program around quickly is easier to do than to make a digital planetarium show or an exhibit.” | “All around, our programs are just easier to accommodate current science.” | “Exhibits take more money and more time.”/Creating template, NSF Grant |
| | 2. Rapid change exhibits | | Museum of Science | (Partnerships with researchers) “These partnerships are the most significant resource that my department gets... They either got leftover grant money or there’s an opportunity for them to do that within their capacity so they give us a call.” | “Having the time to be able to process this quickly and get something on the floor.” | |
| | 2. Rapid change exhibits | | Pacific Science Center | “Money, money, money.” “It’s pretty people intensive, and it’s keeping both staff and scientists trained, and finding the money to maintain the program.” | “We’re grant funded, so looking at different models of funding is where we’re at right now. You want to keep the six month turnaround as much as possible, but each of those is about \$100,000.” | “It’s expensive to do exhibits, and then to think about how to do that on a regular basis so that you’re presenting the most current science.” |
| | 2. Rapid change exhibits | | Science Museum of Minnesota | “We built sort of a library of furniture so that we could reuse it over again. | | |

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| | | | | We still struggled with the turnaround time that it took to get stuff out on the exhibit floor...what that allowed us to do was publish content to the exhibit floor from anywhere.” | | |
| | 3. Programs led by staff | | Museum of Science | “One of them was the idea of a showcase...And we also were going to create what we call the playground.” | | |
| | 4. Encourage the bi-directional nature of science learning and understanding | | Science Museum of Minnesota | (exhibits) “A way of taking some of that science in those exhibits and thinking about what social issues were related to those.” (Childhood development dialogue) | “We have these scenario games where we would ask a question about a topic that had some sort of controversial juice to it...sometimes people knew a lot about something, but they needed an emotional context too. And then they could debate each other in the comments which was interesting.” | “We expanded a lot with the idea of inviting visitors into the conversation and more than just allowing them to respond to us, allowing them to create situations where we had to respond to them.” |
| | 4. Encourage the bi-directional | | Morehead | “Presenting the science in a way that’s age appropriate and the | | |

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| | nature of science learning and understanding | | | discovery doesn't go stale is a challenge." | | |
| | 4. Encourage the bi-directional nature of science learning and understanding | | Museum of Science | "Audience challenge, because the audience that many museums get, including ours, is not necessarily looking for this information...rather than going deep, deep, deep into the science, we want to focus on, 'So what?'" | | |
| | 4. Encourage the bi-directional nature of science learning and understanding | | Pacific Science Center | "We attract very science attentive individuals, they come here because they're interested in science. They would go to a ball game instead. They may not be such science advocates that they're jumping up and down, but they're still interested in science. How do we find ways to get science inattentive people?" | | |
| | 4. Encourage the bi-directional nature of science learning and | | Science Museum of Minnesota | "Some of the problem there is research that is important and institutionally feel visitors need to know about or the NSF feels like the research | | |

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| | understandin g | | | like the public needs to know about, but that doesn't necessarily mean the public thinks they're interested in it." | | |
| | 4. Encourage the bi-directional nature of science learning and understandin g | | Koshland | "The most challenging, from a programming point of view, is how to take something like climate change and try to make it fun and interesting." | "Topical science | "I think having things be really interactive is a way to overcome that challenge." |
| | 4. Encourage the bi-directional nature of science learning and understandin g | | Pacific Science Center | "Presenting current science is actually really difficult. It's complex because it's current. One of the things that we have developed, and actually have a good model for now is rapid turnaround for current science spaces." | | |
| Question 3 | | | | | | |
| What do science museums want their visitors get out of their experiences with current science? | 1. Understand Nature of Science | A. Process | Morehead | "Being on a university campus I think there's something about Morehead providing a window into the way academic research happens and the process here and getting people more inspired and interested in that maybe not to the point where they | | |

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| | | | | want a career in science.” | | |
| | 1. Understand Nature of Science | A. Process | Museum of Science | “And just informing the public, how does science work? How does it happen? How is it funded? How does it progress? There are challenges and hurdles and things that come along the way.” | “And that was to show people how science does things.” | |
| | 1. Understand Nature of Science | A. Process | Pacific Science Center | “That we find out new information every single day and that gets applied and our models change or they don’t That it’s not a static thing. That is something that is viewed in current science and that is something that we make sure we really push across the floor in general.” | “One thing we really thought was for people to understand that scientists are, to a large extent, like everyone else...it humanizes the nature of science and the nature of people who do science.” | |
| | 1. Understand Nature of Science | B. Content | Pacific Science Center | “We certainly hope that they’ll have a better appreciation for not only science content, but more about how scientists go | | |

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| | | | | about doing their work.” | | |
| | 1. Understand Nature of Science | B. Content | Science Central | “Walk out of here with facts and figures.” | | |
| | 1. Understand Nature of Science | C. Implications | Museum of Life and Science | “They’re encouraging the visitors to share their values and talk about how these may be relevant to their lives and how they may be relevant to people in other countries, or developing countries, or how they may help solve problems for other people, and may even be used for nefarious reasons in other areas.” | “We thought early on that conversations were a very good way to go about talking about some of the issues that we faced around current science and technology and whether or not there are some ethical implications, economical implications.” | |
| | 1. Understand Nature of Science | C. Implications | Museum of Science | (Talking about forum) “We realize that those have societal implications in the world that we make decisions about those things as funders, as decision makers, as consumers, as parents, as teachers, as politicians, to figure out how emerging technologies play out in society. | “We have a provocative questions exhibition. Which takes a socio-scientific topic where people can discuss the societal and ethical implications around a questions and create an argument around that through | “More engaged in how science plays a role in our society and understand how it works and value that there are experts that are doing this kind of work and that it’s worthwhile.” |

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| | | | | | conversation.” | |
| | 1. Understand Nature of Science | C. Implications | Science Museum of Minnesota | “How people think about policies that affect their community and their world.” | | |
| | 2. More engaged with science | A. More active/interested | Koshland | “They get something related to the mission of the museum, which is to help people use science to solve problems in their own communities. | | |
| | 2. More engaged with science | A. More active/interested | Morehead | “I think it’s just an interest and engagement with science in general so that they can get excited about what’s happening with science and maybe go home, or go to their classroom and get more involved with it.” | | |
| | 2. More engaged with science | A. More active/interested | Museum of Life and Science | “We can start asking questions that we don’t know the answer to, but we hope our visitors will begin to think about when they start to learn about other technologies, when they read the newspaper, or when they turn on the TV and on the nightly news they see some new current science and maybe they’ll apply the same questions.” | | |

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| | 2. More engaged with science | A. More active/interested | Museum of Science | “I think there’s going to be a more active role in having people think about themselves shaping the future of science.” | | |
| | 2. More engaged with science | A. More active/interested | Pacific Science Center | “The other thing is developing an enthusiasm, an identity with science. How do you get people interested in it?” | “There’s a sense of pride that you are part of a community in which global research impact is happening. | |
| | 2. More engaged with science | A. More active/interested | Science Central | “I’m gonna watch a science show on TV instead of a sporting event. I will read this science article rather than the stock market magazine.” | | |
| | 2. More engaged with science | A. More active/interested | Science Museum of Minnesota | “you’re maybe more of a scientist than you think. Maybe you care about this in ways that you didn’t think you did, maybe it’s just interesting.” | | |
| | 2. More engaged with science | B. Potential career for younger audiences | Morehead | “Think about it as a career and really see that science is expanding and it’s happening around us.” | | |
| | 2. More engaged with science | B. Potential career for younger audiences | Museum of Science | “The researchers that we work with, a lot of their motivations, they get really excited that they can really inspired to pursue their | | |

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| | | | | fields. I think when we talk more with them they understand that there's value to just informing the public about science in general, beyond just inspiring the next generation." | | |
| | 2. More engaged with science | B. Potential career for younger audiences | Science Central | "I would like for them to walk out of here saying, 'Science is fun. I can become a scientist when I grow up.'" | | |
| | 2. More engaged with science | C. Make informed decisions | Koshland | "Learn something that encourages them to take some sort of action when they leave." | | |
| | 2. More engaged with science | C. Make informed decisions | Museum of Life and Science | "We break down the stereotype of who and what a scientist is and how the public should and can play a role in whether or not these technologies are adopted." | | |
| | 2. More engaged with science | C. Make informed decisions | Museum of Science | "Science doesn't make the decision, science informs the decision and the decision comes from all of the stuff that you bring as a consumer and parent. The other goal that I would add is helping to create an | (Talking about forum) "We realize that those have societal implications in the world that we make decisions about those things as | |

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| | | | | informed citizenry that values and appreciates the role that science and technology play in their lives.” | funders, as decision makers, as consumers, as parents, as teachers, as politicians, to figure out how emerging technologies play out in society. | |
| | 2. More engaged with science | C. Make informed decisions | Pacific Science Center | “When they do see these things in the headlines and when certain things do come up that have become politicized, that they are just better informed, and maybe even willing to do a little of their own unbiased research.” | | |
| | 2. More engaged with science | C. Make informed decisions | Science Museum of Minnesota | “We consider science an essential literacy, people are asked to make decisions that in theory should be based on scientific evidence all the time.” | | |

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