Knology

A Research Synthesis:

Addressing Societal Challenges through STEM

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Kris Morrissey, John Fraser, Rebecca Joy Norlander, Kathryn Nock, Theresa Ball
& Kate Flinner

Practical social science for a better world.

Executive Summary

People in the United States feel there are a wide range of critical social issues that face this country. In April 2021, a national poll found that the majority of US residents rate 15 social issues as moderately big or very big problems (Pew Research Center, 2021). These complex issues have shaped ways of life in this country and will likely continue to do so for years to come. To overcome these entrenched problems, the public will need tools for learning about them and charting a path to solutions. One approach will be to equip people with science, technology, engineering, and math (STEM) information, which can be key to both understanding and developing solutions to social problems. But where can people access reliable information and an opportunity to think about action?

Museums and other informal learning environments are places where people can learn about and discuss these topics. These institutions are well suited to the task because they offer enjoyable learning experiences for multi-generational audiences (Sickler & Fraser, 2009). They design their offerings to help their users integrate new understanding into their daily lives, generational knowledge, and novel experiences. They offer multi-sensory experiences that spark affective, cognitive, behavioral, and other types of learning. In particular, informal STEM learning (ISL) institutions -- such as science centers, aquariums, zoos, botanic gardens, and parks -- offer distinct opportunities for addressing social issues. As experts on techniques for STEM learning, ISL organizations have the potential to help US residents address the intersection between STEM and social issues. However, there is a lack of research that aggregates what is known about the impact of museums' collective work on social issues and STEM.

From 2019 to 2021, Knology undertook a project called Addressing Societal Challenges through STEM, which was designed to fill the gap in research. With funding from the National Science Foundation (Award #DRL-1906556), the project investigated how informal learning institutions are advancing the use of STEM knowledge and scientific reasoning to enable individuals, families, and communities to understand what they can do, and apply their learning to solving critical societal challenges. The team of researchers wanted to look specifically at what has been accomplished in the last 20 years, including what has changed in that time and whether there are still untapped opportunities for museums.

To accomplish this goal, the research team looked at literature about this topic in three separate online libraries: papers published in peer-reviewed journals, reports posted on InformalScience.org, and theses and dissertations published on ProQuest.

One of the first orders of business was to identify which social issues to focus on in the search for literature. Researchers used a theoretical framework developed by sociologist Joel Best, which defined social issues as conditions that the public and experts widely recognize as harmful or limiting society. To identify social issues that fit this definition, we used topics from national polls as well as topics that were mentioned in State of the Union addresses.

This generated a list that included healthcare, climate change, immigration, racism, corruption, equality, incarceration, and many more issues.

What We Found

With this approach, the research team uncovered 237 papers published from 2000 to 2019. Our analysis uncovered the patterns in the topics that museums focus on, how they address social issues, the relationship between social issues and STEM, impacts of this work, and the implications for the museum field. Here's what we found:

The literature indicated museums research centered around three primary topics: climate change, race and health. Institutions with missions that focus on science learning, like science centers and zoos or aquariums were much more likely to focus on climate change and health. Other issues that rated as top concerns in opinion polls -- such as the economy, gender, and poverty -- rarely showed up as the focus of these publications. The literature also suggested there may be differences in the social issues that different types of informal learning institutions concentrate on. For instance, the vast majority of mentions of climate change showed up in projects that took place at STEM-focused institutions, as opposed to other types of museums.

Museums leveraged STEM to inform audiences about the nature of a social issue and primarily focused on using science over other disciplines. Publications showed that museum projects about social issues prioritized STEM learning as a way to inform and build knowledge about social issues. A few projects also used social issues to engage people in STEM learning. Across the inventory of publications, the word *science* showed up nearly 14,000 times, compared with *technology*, *engineering*, and *math*, each of which appeared fewer than 1,000 times.

Museum projects about social issues most commonly revolved around two areas of impact: knowledge growth and sparking changes in behavior. To a lesser extent, projects also focused on impacts related to attitudes and values, enjoyment, reasoning, and institutional capacity building. While many projects aspired to seed social change, they typically focused on impacts at an individual level rather than across a community. Measuring actual behavior change presented a challenge for projects about social issues, with most relying on audiences' intentions to change their actions.

Some, but not all, of museums' work on social issues was grounded in theory, and methodological approaches varied in these projects. Some types of literature drew from theory more than others, with theses and dissertations most commonly citing theoretical frameworks. For studies that reported on their methods and were designed around STEM, surveys and interviews were the most common methods. Generally, studies prioritized the distinct circumstances of an intervention, describing the specific contexts, outcomes, and limitations of exhibits and programs. Meanwhile, there was less attention paid to comparisons between museum audiences and the general public.

What to Do with this Research

Our findings suggest that museums and other types of informal learning organizations will continue to explore the intersection of social issues and STEM. We support ongoing experimentation because it fulfills these institutions' promise of service to their communities. There are several heuristics that can guide this work (Morrissey, Fraser, & Ball, In Review). Heuristics, or adaptable strategies, can inform decision making in a landscape where there are many unknowns, such as museum projects on social issues and STEM.

This project clearly has implications for museum professionals who work directly on exhibits and programming that address social issues and STEM. The findings are also relevant to many more types of professionals whose work relates more broadly to informal learning settings. In fact, all of these roles are critical to the success of these projects. Funders make key decisions about which projects to nurture when they are in the process of development. Institutional leaders steer projects in line with an organization's mission. Public-facing workers -- including educators, guest services professionals, marketers, and security guards -- shape interactions and messages for the museum's community. Researchers and evaluators help conceptualize the meaning of a project for the community and how to understand it. With all of these roles in mind, we offer the following heuristics to support museums' work on social issues and STEM.

Focus on *how* and *when* to engage with social issues, rather than *if*. When approaching social issues and STEM, museums will need to decide what is appropriate and useful for their community and how that fits within their institutional mission. Working on social issues will involve a degree of advocacy and risk, which a museum should be prepared to navigate when undertaking a project.

Develop and support talent. Embarking on new and potentially provocative topics requires additional preparation and training for museum staff, especially those who are in public-facing roles. Museums can reflect on the best ways to invest in professional development for all types of workers who may be involved in supporting a project on social issues and STEM. By extension, this training will also benefit audiences.

Don't ignore societal systems and forces. Social issues do not develop in isolation; they are shaped by interrelated economic, social, political, and behavioral conditions. Similarly, STEM can be involved in both the nature of these problems and potential solutions. Projects in museums should embrace the complexity of social issues, the need for collective approaches to solutions, and the relationships between the disciplines that are a part of STEM.

Collaborate outside of the box. Just as complex social issues require solutions that draw from different perspectives, so too should museum projects encompass multiple types of expertise and institutional experience. Partnerships should expand beyond the "usual suspects" to include organizations in all sectors, such as government agencies, charitable organizations, and businesses.

Acknowledge inequities. Ignoring disparities in social issues can perpetuate the harms caused by these problems. Museums have an opportunity to give voice and authority to

those who have been disproportionately affected by social issues. At the same time, institutions should acknowledge inequities and work toward resolutions on an internal level as well.

Rethink how to measure success. When addressing social issues and STEM learning, evaluation may need to consider new ways of measuring impact. Specifically, studies will need to examine social change at the community level to understand a project's outcomes and paths for future work.

Products from this Research

The research team prepared the following products to communicate the research results and process:

Knology. (2021). Addressing societal challenges through STEM: Inventory (Version 1). [Data file]. Retrieved from: https://bit.ly/2SoxBsk

Knology. (2021, May 19). *Social Issues & STEM in museums* [Video]. YouTube. https://www.youtube.com/watch?v=WizndNT15aw&t=2s

Fraser J. (2021). Literature synthesis research. *Curator: The Museum Journal 64*(3), 417 – 419. DOI: 10.1111/cura.12438

Fraser, J., Norlander, R.J., & Nock, K. (2021). Methods that reveal and conceal: What the literature says about museums, STEM, & social issues. Manuscript submitted for publication.

Morrissey, K. (2021). *Research synthesis: Challenges and opportunities of an evolving methodology.* Knology. https://doi.org/10.13140/RG.2.2.13810.63680/1.

Morrissey, K., Ball, T., & Fraser, J. (2020). Museums, STEM, & social issues: An ongoing conversation. *Informal Learning Review*, *164* (November/December), 13-17.

Morrissey, K. & Ball, T. (2021). The role of the ISL field in addressing social issues: A matter of capacity and intention. Manuscript submitted for publication.

Morrissey, K., Fraser, J., & Ball, T. (2021). Museums and social issues: Heuristics and professional practice. Manuscript submitted for publication.

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Introduction

In 2019, Knology launched a new research project called Addressing Societal Challenges through STEM (ASCs), with funding support from the National Science Foundation (Award #DRL-1906556). This two-year Literature Review and Synthesis project was designed to answer the question: How are informal learning institutions advancing the use of STEM knowledge and scientific reasoning in ways that individuals, families, and communities: 1) understand what they can do, and 2) apply their learning, to solve the societal challenges of our time?

In the past two decades, informal STEM learning (ISL) organizations have increasingly engaged in innovative ways to present STEM knowledge within the context of societal challenges. Researchers have observed that social issues have moved from the fringe of museum work to what many describe as museums' core focus (Sandell & Nightingale, 2012; Sandell, 2017). ISLs have explored a wide range of social issues, including climate change, energy sources, cyber-security, nanotechnologies, coastal resilience, and more. Together, these efforts appear to expand the traditional work of ISL organizations, often leading to new types of interventions, partnerships, impacts, and assessment tools.

To best serve ISL organizations in addressing social challenges, we examined how museums, broadly defined, address the intersection between STEM and social challenges.

Our project used a literature review and synthesis approach to analyze and interpret the aggregate of the published work surrounding this shift, with the goal of advancing theoretical and practical knowledge about the potential of museums to advance the role of STEM in addressing societal challenges. The research questions were:

1. What types of issues are addressed or not addressed?
2. Is STEM situated within the issues and if so, how? (Does the project deliberately and transparently discuss STEM information or scientific reasoning?)
3. What types of impacts are intended, measured, and achieved, and for which audience?
4. Are there relationships between audience, impacts, STEM discipline, and the type of issue?
5. Is the work informed by, or shaped by, theories or theoretical constructs?

Literature Review & Synthesis Approach

Systematic reviews can be a research method for generating new knowledge, rather than the traditional use of reviews for summarizing literature as a precursor to research. For this project, we used a **configurative literature review** approach, distinguished from a meta-

analysis in the nature of the literature reviewed and the goal of the review. A meta-analysis aims to "add up" the findings across homogeneous studies, most often through quantitative assessments. In contrast, we used a configurative literature review because of the preponderance of qualitative research in the ISL field, the heterogeneity in how research is reported, and our interest in answering broad research questions and theory-building rather than measuring size of effect. Configurative reviews consider what is addressed in relation to a topic and how, rather than comprehensively document all data represented within the area of study (Gough, Thomas & Oliver, 2012).

The approach for a configurative review grows out of grounded theory work (Creswell & Poth, 2018; Devlin, 2018; Merriam & Tisdell, 2016) and is inquiry-based and qualitative in nature. It follows common principles and a specific (although flexible) research-based protocol for the selection, analysis, and synthesis of the literature with the goal of producing new knowledge that advances "evidence-informed decision making" (Gough, Oliver & Thomas, 2012, p. 250). A question-based, iterative process is used to map, organize, analyze, and synthesize heterogeneous sources to describe "the state of knowledge" and to identify "important issues that research has left unresolved" (Cooper, 2010, p. 4).

We used three primary sources for identifying relevant literature: peer-reviewed journals, graduate theses, and evaluation reports of federally funded projects posted on the Center for Advancing Informal Science Education platform (InformalScience.org). We selected those literature repositories because they each represent some form of formal peer-review of the value of the work to the field. Specifically, publications in peer-reviewed journals are subject to review by topical experts; published graduate research is overseen and accepted by faculty who are often recognized experts on the topic of study; and the rationale and methods for federally funded projects posted on informalscience.org are typically subject to external expert review before funds are awarded.

Our research was bounded by the scope of these three sources. As a result, we did not try to determine the status of the overall ISL field. Instead, we tried to describe what scholarly publications say about the field.

Project Team

The project team consisted of a group of researchers and writers from Knology with experience in museums and other informal learning institutions. Kris Morrissey served as Principal Investigator, and John Fraser served as Co-PI. Kate Flinner served as executive editor. Rebecca Norlander, Theresa Ball, and Kathryn Nock served as researchers. A panel of advisors provided input on bodies of literature, results, and implications. This group included Troy Sadler, Stephanie Ratcliffe, Tonya Matthews, Joan LaFrance, Kevin Crowley, and Marjorie Bequette. Crowley and Bequette also served as external reviewers and led the evaluation of the project's methods and conclusions.

This Report

This report describes the project process, research findings, and evaluation outcomes. It draws from the several papers that were submitted to academic journals, our proposal to the National Science Foundation, and input provided by project advisors. In particular, we document the procedures that we established to build our inventory, and the challenges we encountered in the process. We hope this information is useful to research teams that pursue literature synthesis projects in the future.

Methods

One of the central activities of this project was building an inventory of publications to study. We used three bodies of literature: (1) Peer-reviewed journals; (2) Graduate theses and dissertations published through ProQuest; and (3) Evaluation reports posted on InformalScience.org. These three bodies were selected based on our understanding that they represented some level of accountability and peer review. Across all three sources, we included literature that was published from 2000 to 2019, which focused on research or practices in the United States.

We divided our team into two groups, based on their location: Seattle and New York City. The groups used slightly different protocols to build the inventory. By combining two separate approaches, we hoped to decrease the chance of missing relevant papers in our inventory. This approach also enabled us to triage how one team might have identified a paper for inclusion that the other team did not.

Building the Inventory

There were three main criteria that shaped our approach to building the inventory:

1. The literature was published between 2000 and 2019.
2. The literature focuses on projects or research based in or about informal learning environments.
3. The project or research addresses a topic that is viewed or presented as a societal challenge.

These criteria informed the sources of literature and the search terms we used. Below, we explain the details of each criterion, as well as challenges we encountered.

Bodies of Literature

Criterion 1: The literature was published between 2000 and 2019.

We included a 20-year period in our search terms, from 2000 to 2019. Given that we finished building the inventory in November of 2019, publications from the last few months of that year were excluded.

The team also recognized that publications from our literature sources likely reflected projects that began several years prior to publication, due to the nature of funding and the peer review process. While this circumstance did not shift our inclusion criteria, the team sensed it would influence the implications of the research.

Criterion 2: The literature focuses on projects or research based in or about informal learning environments.

Though the project focuses on ISL institutions, our search included informal learning institutions more broadly, as a way to understand how the field as a whole is addressing STEM and social issues. We focused on museum settings that provide educational opportunities that are voluntary and self-directed in a location outside of a formal school. We also ensured a focus on informal learning by selecting peer-reviewed articles, theses, and dissertations, from journals relevant to the museum field. We also focused on studies posted in the InformalScience.org library that occurred in an ISL institution.

Although there is considerable overlap in the goals and activities of many formal, informal, and non-formal organizations, we focused on literature describing projects in or about museums based on the unique characteristics, potential, and limitations of the type of experience they offer. Museums have become a focal point for informal learning research as they offer educational opportunities for a wide variety of audiences that are far different than formal in-school learning (Crowley, Pierroux, & Knutson, 2014; Rogoff, Callanan, Gutierrex, & Erickson, 2016). Museums also remain trusted sources for gaining STEM knowledge relevant to those social issues within a larger ecology of places where informal STEM learning occurs (Gupta et al. 2020).

For this reason, we included a broad definition of museums where this type of informal STEM learning was likely to occur, including: aquariums, botanical gardens, historical societies, historic sites or houses, museums, nature centers, planetariums, science centers, and zoos (Gupta et al. 2020). We excluded the following: formal education institutions, after-school programs, civic clubs, and other organizations or entities that support informal learning but would not be included in the International Council of Museums (ICOM) definition.

Our team of researchers in Seattle used over 100 research databases through the University of Washington's library to search for peer-reviewed journals and graduate publications that met our criteria of a project addressing a social issue in an informal learning environment. The search was not limited to specific journals. At the time of this study, the University of Washington library had 180,000 individual electronic journals and 250 library-licensed databases available for use. The ProQuest database, used to search for theses and dissertations, is the most comprehensive collection of dissertations and theses in the world.

Our New York research team used Criterion 2 to compile a list of journals that specifically focus on topics relating to museums (Appendix B). To manage the scope of this project, they set these journal titles as search parameters for comparing their database search with the results developed by the Seattle team, who did not limit the search to these topic-based publications.

In some cases, a journal that was considered potentially relevant but was not available in the database accessed by the New York team (e.g., Journal of Education in Museums) was

accessible to the Seattle team. Both teams also searched for relevant graduate papers published in ProQuest Dissertations and Theses using search terms described below.

Developing Search Terms

<u>Criterion 3</u>: The project or research addresses a topic that is viewed or presented as a societal challenge.

Determining whether a topic is a societal challenge was the most challenging part of this research, but the validity and usefulness of the results are dependent on the clarity of this criterion and the consistency used to apply it.

We based our definition of a societal challenge on theoretical constructs about social problems. Our approach to this definition was inspired by the work of sociologist Joel Best (2012, 2016), who studies the role of argumentation and persuasion in the ways that society frames a condition as a social problem. Since a population's perceptions of situations and conditions are shaped by a context that changes over time, Best argues that any specific condition becomes understood and accepted as a societal problem only when "the fund of words, ideas, images, and emotional reactions that most people understand to be reasonable claim that the situation is a problem" (Best, 2016, 54). In other words, a condition begins to be viewed as a social problem when the public or the media make substantial claims that the condition is a problem and offer justifications for why the condition should be changed.

In this framework, conditions that are considered to be social problems usually share these characteristics: 1) They are harmful or limiting to a significant proportion of society; 2) They are complex, systemic, and enduring; 3) They require a shift in societal structures, expectations, or behaviors; and 4) There is a lack of social agreement on the nature of the problem or the nature of the solution. Using this understanding of social problems, we defined a societal challenge as a social problem where: STEM knowledge and scientific reasoning are necessary to understand and to respond; and there are claims or warrants for ISL organizations to engage in the problem. We defined societal challenges as problems where STEM knowledge is embedded in the path towards a solution.

In the context of our search protocol, we focused on literature that contained internal or external claims about a societal challenge. For internal claims, we mean that the project or the research made claims to address a *social problem*, *social issue*, *societal challenge*, or similar terms embedded in our definition of a social problem. By external claims, we mean that the project or research addressed a topic that was viewed by the public as a social priority.

The New York team searched the internet for common public opinion polls to generate a list of terminology used to talk about social issues. These included Pew Research Center, Cable News Network (CNN), The Washington Post, Gallup Poll, The Wall Street Journal, and The National Broadcasting Company (NBC). They also identified social issues that arose in five Presidential State of the Union speeches from 2015 to 2019 as a way of capturing current

social issues. Both searches served to highlight the terminology used in the media to discuss social issues, and the issues featured in national narratives. Two researchers grouped the words and phrases into categories, and then selected a phrase that best captured the idea behind each category and would most likely yield results in journal searches. See Appendix A for the list of terms.

The Seattle researchers developed a list of topics that were based on their standing within public opinion polls that are viewed as reliable. They used Nate Silver's rating of opinion polls as a primary indicator, with the caveat that the polls included in that study primarily looked at election results (Silver, 2018; Five Thirty Eight, 2021). Using that rating of opinion polls, they relied on opinion polls that Silver assessed as neutral and a selection of polls on either side of neutral. They documented the topics covered by these opinion polls and looked for topics that appeared on multiple lists. Sometimes this resulted in collapsing or renaming topics or expanding topics. For example, incarceration or prison reform were used differently and additional terms were added, such as *reproductive rights* (from searches on *abortion*) and *food security* (from searches on *poverty*). From that, researchers developed the list of keywords used for searches (Appendix A).

Checking for Gaps

To limit the number of articles missed in the search done by New York researchers, we built in two checks. The first check was designed to ensure that everything relevant from a sample journal had turned up. To accomplish this goal, a third researcher who had not previously been part of the search process manually reviewed the physical archive of *Curator: The Museum Journal* to check for relevant articles that fit our criteria. The second check focused on assessing the degree to which our list of social issues was appropriate, useful, and comprehensive. To do this, the same third researcher reviewed the table of contents for all issues of *Museums & Social Issues* online (without having seen the results of the database export), as this was the place relevant issues were most likely to appear. These lists were added to the inventory and reviewed by the Seattle team.

STEM as Variable vs. STEM as Inclusion Criterion

The project team struggled to come to consensus around how to approach STEM. We summarized that issue by thinking about social issues that could, should, or did have a link to STEM in the research. While we were not in full agreement on even this parsing, the New York team felt the project should focus only on projects that demonstrated a direct link between the STEM content and a social issue. The Seattle team that developed the inventory used a more expansive definition, ,looking at the work produced by ISL institutions around social issues, and then worked to code whether STEM was embedded in that work. On this basis, it was agreed that the Seattle team would create the full inventory, and that the New York team would then work with the subset of content relevant to their approach.

The New York researchers conducted an analysis of methods in their subset of the inventory to understand the epistemic underpinnings of projects involving social issues and STEM. For

this study, they reviewed all articles in the inventory for explicit inclusion of STEM content connected to engagement with the social issue. STEM was defined as content that fits within the National Science Foundation categories of science, technology, engineering, and math knowledge. We reviewed all articles for the presence of STEM in some way. They included STEM in the topic of the exhibit, STEM as a tool for understanding social issues covered in the exhibit, or the use of STEM as a solution to a social issue. They first reviewed the abstracts. If STEM was mentioned in the abstract, they then downloaded the full text for further review (Fraser, Norlander, & Nock, 2021). If the article did not have an abstract, researchers did a word search for STEM and each of its component parts in the full article text. We recognize that the approach to abstracts may have excluded some articles that do mention a STEM topic at some point in the full text. To minimize subjectivity for this criterion, two researchers examined the inventory independently and coded each article for inclusion or exclusion. They then discussed those where only one researcher felt the paper should be included; inclusion in this study was confirmed by consensus of the coding team. A post-hoc review of the New York team's subset was undertaken by the PI. This review turned up several papers not originally nominated for analysis by the New York team. This led the co-PI to incorporate two additions and three corrections to complete the subset of the inventory used for the New York researcher's analysis.

Inventory Considerations

When the project team combined the inventories generated by Seattle and New York researchers, they found there were a series of questions and discrepancies around the characteristics of articles where the two inventories didn't match. The group discussed each of these characteristics to reach a final decision about inclusion. We considered the following areas:

- **Museum Operations** - Many articles about relevant topics related to museum operations (e.g., diversifying staff, how to make the museum building more sustainable, the effect of climate change or terrorism on museum insurance rates). But they did not focus on visitor audiences or the public. These were not included in the inventory.
- **Study Location** - The researchers who relied on journals specific to museum topics assumed that articles would be about museums as informal learning sites. However, some articles were about research at different sites. These were excluded from the inventory.
- **International Studies** - Generally, studies that occurred outside of the US were excluded. However, we included two studies that included museum research both within and outside the US. For example, a study by Fiona R. Cameron (2012) was conducted at the Liberty Science Center in New Jersey and the Australian Museum. That and another study were retained in the inventory.
- **Historical & Current Events** - Some recent publications were about historical events. Even though the publication date was within our time window, the events discussed were not. These were typically excluded, except if the abstract indicated a strong connection to a contemporary social issue. For instance, one article discussed the

system of slavery in the US linking it to current problems around racial profiling and discrimination.

- **Study Focus -** Our searches came up with studies describing social issues as they relate to museums, but they did not describe interventions about these topics. For instance, some articles discussed the lack of demographic diversity in museums or problems relating to classism and elitism in the museum field. These articles were excluded from the inventory since they did not focus on a specific intervention.

Overall, the choices were systematic, deliberate, and protocol-driven, and therefore we present our inventory as an accurate representation of the literature describing museums' engagement with the intersection of social problems and STEM. At the same time, we recognize that we made decisions about our data sources that might have limited the comprehensiveness of our inventory and the subset. As a result, we do not assume or claim the inventory is exhaustive or without subjective decisions.

The Complete Inventory

The total inventory featured 237 publications from 2000 to 2019. It consisted of 110 articles from peer-reviewed journals, 50 articles from InformalScience.org, and 77 theses and dissertations. We have made it available for open access download in an Excel spreadsheet at https://bit.ly/2SoxBsk. This spreadsheet includes the following:

- **Full Inventory** - This sheet features a bibliography citation for each article, as well as ID numbers we assigned to each one.
- **Environment & Category** - This sheet features several ways that we categorized the papers: paper type (i.e., empirical, descriptive, or expository), the type of institutional environment (i.e., informal STEM learning institution, or general informal learning setting), and whether the paper described research impacts.
- **Methods & Sample Sizes** - This sheet features a subset of 110 articles that described both the research methods and the data analysis for the study. We include the types of methods each study reported using, as well as whether the sample size was large enough to perform statistical testing.
- **Codebook** - This sheet provides details on the codes used in the other sheets.

Analysis

We reviewed the entire inventory or portions of it for the following information:

- **Type of Institution** - We determined whether the studies took place in institutions that were described as STEM-based (e.g., zoos, aquariums, science centers, science museums, nature centers) or other types of institutions (e.g., history museums, art galleries, children's museums)
- **Type of Study** - We determined whether the study was empirical (paper includes research questions, methods, and results), descriptive (describes a project or initiative) or expository (states a position or calls for action).

- **Range of Issues** - We used the full set of studies to identify the range of topics addressed, as well as the gaps between topics addressed and topics of public concern.
- **Intended & Achieved Impacts** - We developed a coding system that was adapted from the Generic Learning Outcomes developed by the Arts Council England and the six strands of informal STEM learning identified by the National Research Council (NRC, 2009). For the papers about projects that took place in ISL institutions, we then compared intended impacts with achieved impacts and also looked for relationships between impacts, topic areas, audiences, and types of interventions.
- **Intended Audience** - We coded and compared studies by intended audience (e.g., public, adult, youth, school groups, professionals, other).
- **Type of interventions** - We also coded studies by the type of intervention they described (e.g., exhibits, programs, collections, dialogue programs, research, other).
- **Methods** - We examined the types of methods used in a subset of 110 studies that explained their methodological approaches and the implications of the valence (or what types of knowledge are preferred) uncovered for future research. Methods included surveys, interviews, focus groups, observations, document reviews, journaling, and other types of methods.
- **Sample Sizes** - We investigated the sample sizes in 71 papers that provided information about the number of research participants.

Findings

Our analyses produced a wide range of results, which address our research questions, as well as other considerations that may be important for the field. This presentation represents findings as they were structured in the original manuscripts submitted for publication, prior to peer-review. We recommend that readers seek out final publications as noted elsewhere in this report to confirm if any changes were made subsequent to this publication. The chapter is organized according to the research questions.

Topics & Issues

We examined the inventory to gain insight into our question: **What types of issues are addressed or not addressed?** We compared the social issues discussed in the papers to the issues represented in our search terms. We found that the papers focused on some social issue topics extensively (e.g., climate change), while not addressing others at all (Figure 1). Some of these other social issues -- such as immigration, incarceration, and poverty -- were not often covered in papers about ISL organizations, but did surface frequently in papers about other types of museums.
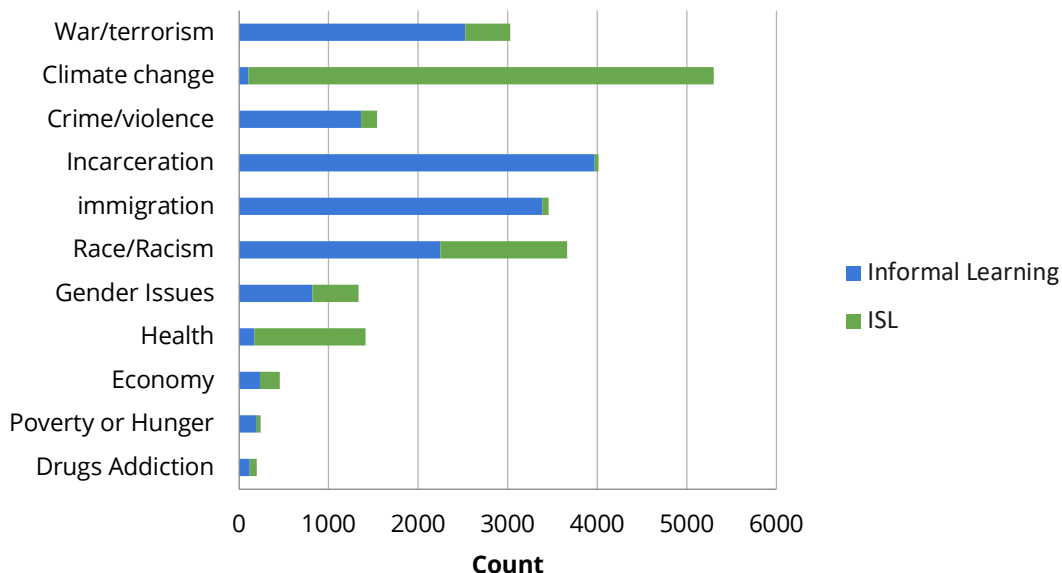
Figure 1.   Terms relating to social issues found in opinion polls, compared to the frequency of these terms in papers for different types of museums (*N* = 237 papers).

Climate change was the most common topic with a range of mostly STEM-based institutions offering exhibits, programs, and research. Earlier projects were more likely to focus broadly on the topic of climate change and more recent projects on specific implications of climate change, particularly as related to the mission of the institution. For instance, there were

aquarium projects focusing on ocean acidification, and zoo programs on the loss of biodiversity as a result of the climate crisis. Health was common across a wide range of institutions and projects. But specific topics recognized as social issues -- such as the opioid epidemic, healthcare policy, mental health, and depression -- did not feature in the projects described in our inventory.

There were very few examples of addressing gender-related controversies, reproductive health, gun regulation, immigration, or economic disparities. The few exceptions included an exhibit about mental health (Winfrey & McDonald, 2016), an exhibit about a family with a trans grandparent (Middleton, 2016), and a dialogue-based program about reproductive choice (Wagner, Eckler & Leighton, 2013).

Science, Technology, Engineering, and Math

At the outset of the project, we asked, **Is STEM situated within the issues and if so, how? Does the project deliberately and transparently discuss STEM information or scientific reasoning?** We found that museums took two approaches to using STEM in interventions related to social issues. First and most common was using STEM information and building STEM knowledge to help people recognize and understand the social issue. Second and much less common was using the social issue as the entry point into learning about the STEM underlying that topic.

By far, studies focused on science as opposed to technology, engineering, and math (Figure 2). There were also a few examples of STEM featuring as a *solution* to a social issue. For solutions-oriented framing, engineering was the most common, particularly around energy (e.g., nuclear energy) and medical advances (e.g., nanotechnologies).
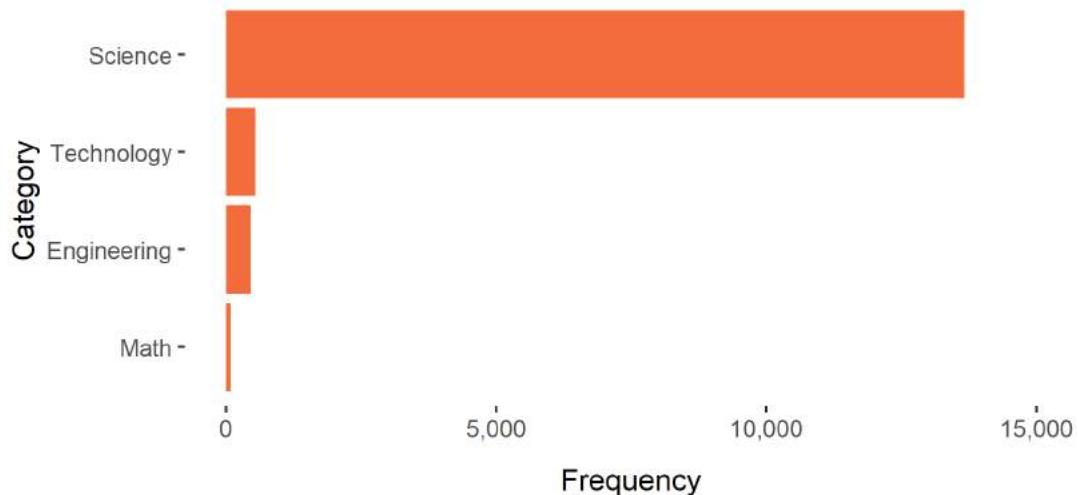
Figure 2.   Frequency of mentions of Science, Technology, Engineering, and Math in the 237 papers in the inventory.

Exhibits were the most common type of practice described. We also observed an impressive range of other interventions, including dialogue-based programs, media-based programs, camps, interpretive approaches, and professional development initiatives. There were few examples of collections development related to social issues, with the exception of several

projects related to current events such as the Black Lives Matter movement (Salahu-Din, 2019), changes in same sex marriage laws (Clark & Wexler, 2008), and the protests of the Dakota Access Pipeline on the Standing Rock Sioux Tribe's lands (Kieffer & Romanek, 2019).

Impacts

One of our research questions was, **What types of impacts are intended, measured, and achieved, and for which audience within ISL projects?** We analyzed studies that reported impacts for projects that took place within ISL institutions. We observed that, to varying degrees, projects in the inventory attempted to achieve the six types of impacts we had identified based on the Generic Learning Outcomes and the six strands of informal STEM learning (Figure 3). These interventions were most frequently designed to build audiences' knowledge about a social issue, which was also the highest area of achieved impact. However, we caution that knowledge outcomes were typically measured through participants' self-assessments. Behavior or attitude change was the second highest area of intended impact. Many studies showed that enjoyment was an unintended yet common impact.

Figure 3.   Count of papers that identified intended and achieved impacts organized into six categories ($n = 72$).

Social change was a commonly stated aspiration. We found that projects did not measure these impacts in communities or societal structures, but rather focused on individuals. Intended actions or behavioral changes were often reported, but not actual or observed changes. While participants were likely to identify the presence of social problems within the exhibit, they were less likely to show an in-depth and nuanced understanding of the complexities of issues like race or healthcare (for example, see Randi Korn & Associates, 2007, or Haupt & Povis, 2017).

Determining the relationship between changes in knowledge and changes in behavior was a large challenge for projects that wanted to impact audiences beyond increasing their knowledge and awareness of social challenges. Though the majority of studies we reviewed included this goal, evidence of behavior change appeared in few studies. Those that did assess behavioral impacts tended to be professional development projects. Measuring skills related to critical thinking and reasoning also provided a challenge, though some studies reported success in this area.

Findings varied on visitors' reactions to seeing social issues addressed within ISLC settings. Participants in some studies advocated for more direct coverage of social issues and found them inspiring, while participants in another found the messages to be "preachy, political, intense, in- your-face'" (Randi Korn & Associates, 2011, p. 25).

Connections between Audience, Impacts, STEM Disciplines, & Social Issues

From Individual to Societal Focus

Inspiring or creating change at a societal level was expressed as a goal in the majority of articles in the inventory. This trend aligned with field-wide priorities expressed by organizations like the Association of Science and Technology Centers, the Association of Zoos & Aquariums, and the American Alliance of Museums. However, the majority of studies focused on change at an individual level, particularly changes in audiences' daily lives. For instance, a health project attempted to "change their eating habits" (Carney et al., 2009, p. 246), and another project promoted "taking action to address climate change, such as composting, recycling or saving energy" (Randi Korn & Associates, 2011, p. 14).

However, too much emphasis on change at an individual level means that complicated, overlapping and often competing structures that bolster social problems can go overlooked. The National Network for Ocean & Climate Change Interpretation (NNOCCI) project called out this error as "the individual solution trap," manifested in interpretive messages that ignore the factors that contribute to the effects of climate and ocean change. According to one study related to the NNOCCI project, this focus can "prevent the public from understanding the appropriate points of intervention" (Bunten & Arvizu, 2013, p. 268).

The *Race: Are We So Different?* initiative was one of the more promising projects that attempted to address social issues at a societal level. This exhibit "hoped to demonstrate to visitors that racism exists at the societal level, not only at the individual level, and that each individual's personal identity, (regardless of what "race" one identifies as) is embedded within the broad context of institutional racism" (Randi Korn & Associates, 2007, p. xii). A handful of papers in the inventory analyzed the dynamic ways this project approached system-level understanding and solutions. It fostered dialogue among audiences, integrated different disciplines, and was used in university courses.

Building an Infrastructure for Addressing Social Issues

The literature suggested there is a growing support system for museums addressing social issues. First, our inventory indicated there was a growing number of collaborations across institutions and sectors, though most of these partnerships involved larger institutions. Second, the body of literature about social issues in museums grew over time, with the number of studies more than tripling in the second half of our sampled time period. Third, there is a small but increasing number of professional development initiatives designed to improve professional practice in ways that have direct effects on interventions.

Collaborative Efforts

The projects featured in the inventory documented collaborations between similar types of institutions, especially ISL organizations, though there were some that brought together museums of different types, such as history and art museums. There were also partnerships among institutions with different areas of expertise, though we found this in a minority of papers. Cross-sector collaborations, such as those recommended by research on collaborative impact, were rare. There were also collaborations with community organizations that were designed to enable museums to reach broader audiences; these organizations included clubs, religious organizations, and schools.

Growth of Literature

The number of publications on this subject from the last decade is far greater than the number published in the previous decade (Figure 4). These studies come from a diverse range of journals (e.g. *Journal of Microbiology & Biology Education*, *Journal of Museum Education*, *Journal of Community Health*, *Political Communication*, *Museums & Social Issues*, and *Science Communication*), and theses and dissertations represented over 30 diverse disciplines (e.g. anthropology, gender studies, science communication, American Studies, rhetoric, philosophy, etc.). The range of disciplines ensured a vast range of methodological and theoretical frameworks present throughout the inventory for both journal articles and theses and dissertations, though reports from InformalScience.org were less diverse in their disciplinary approaches.
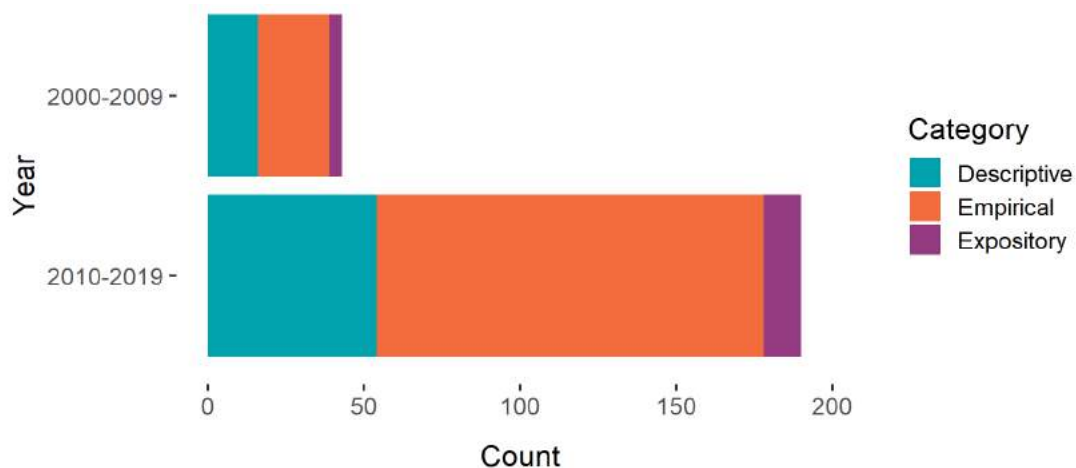

Figure 4.   Count of papers relating to social issues and STEM, according to the type of paper.

Though there was a small number of documented professional development interventions, findings suggest that these efforts had a positive impact on those involved -- both participating professionals and the audiences they engaged with.

As an example, the NNOCCI project emphasized changing the ways professionals communicate messages regarding conservation "from ineffective, passive or crisis frames to more empowering, solutions-based frames" (Pope & Selna, 2013, p. 280). The study showed that the professional development on framing and communication resulted in "more effective climate change communication among informal educators and, as a result, increased visitor engagement" (Geiger et al, 2017, p. 241). Comparing professional development and project impact is notable and important to the ISLC field, where professionals come from a range of backgrounds and can lack a shared pedagogy or skill base.

The Role of Theory

At the outset of our project, we asked **Is the work informed by, or shaped by, theories or theoretical constructs?** We wanted to know whether and how projects on social issues and STEM are shaped by bodies of theory and disciplines from the social sciences and learning sciences.

In the inventory, most of the theses and dissertations were grounded in theory or theoretical constructs, much of the Informalscience.org referred to theory, and only some of the peer-reviewed literature did so. A selection of the theories that were cited includes, but is not limited to: sociocultural learning theory, communities of practice theory, Indigenous theory, geography and critical theory, public history theory, political theory, feminist theory, queer theory, literary theory, and theory of memory.

The publications offered ample evidence of their methodological approaches to understand the epistemological traditions used in museum studies. This prompted us to explore methods descriptions in order to learn how the museum field knows what it knows about projects on social issues and STEM. By extension, we thought this understanding of the relative strengths and weaknesses of such initiatives could help the field continue to advance this important work.

The Role of Methods, Sampling, & Analytic Approaches

To understand the role of methodology in projects at the intersection of social issues and STEM, the New York team examined a subset of the project's inventory that met two criteria: 1) the study included a description of methods, and 2) the study presented a clear STEM-related focus. As a result, our dataset consisted of 110 documents from the full inventory of 237 publications. This dataset included 31 peer-reviewed articles, 46 evaluation reports, and 34 dissertations or theses. These documents described 129 unique studies (including, in some cases, parallel or sequential studies used for triangulation by the researchers). Overall, they used a wide range of social science methods, with surveys and interviews being the most common methods (n = 62 and n = 52, respectively).

For this effort, the New York team employed an inclusive definition of research participants to include auto-ethnography and professional opinion, two types of study that do not assume either anonymity or institutional human subjects review. They used sample size as a unifying proxy that could indicate the degree to which qualitative and quantitative methods were represented in the sample. That dataset was then assessed to reveal valence in the overall subset through the lens of mixed methods research theory, with a specific focus on the epistemic leanings that emerge when some methods or choices are given preference or dominate in a research setting.

To address concerns that emerged from the use of sample size as a proxy, the Seattle team engaged in a critical review of the New York team's results, identifying possible anomalies in the data and querying the coding scheme. This review led to the inclusion of three studies excluded from the original sub-sample, and the correction of two coding errors.

We examined sample sizes in the dataset to understand the degree to which studies were representative of their audiences, and whether these studies could yield comparisons with general populations. In this dataset, 71 papers provided information about sample size, and within these papers there were 130 separate studies. We looked at patterns of sample sizes and found trends according to the source of the paper, with peer-reviewed papers (excluding one outlier with over 7,000 participants) having a median sample size of 116.5, theses and dissertations with a median of 28.5, and InformalScience.org papers with a median of 82. Across the dataset, a substantial majority of papers had fewer than 300 participants (Figure 5). We considered sample sizes to be small if they fell below this 300-participant threshold because statistical tests could not generalize beyond 5,000 people.
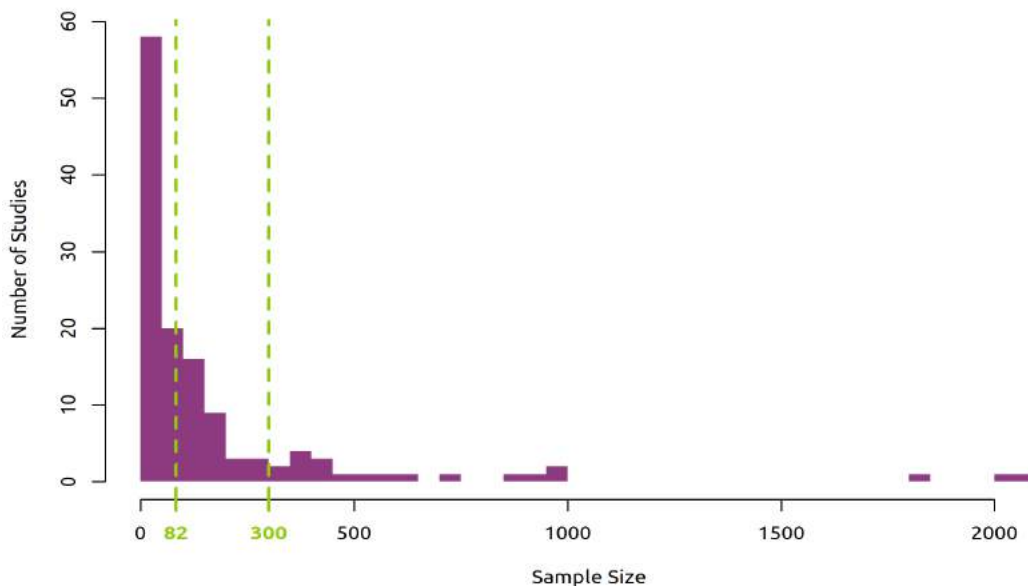

Figure 5.   Sample sizes compared to the number of studies relating to social issues and STEM in museums.

Note.   The 300-participant sample size is indicated to denote the point at which sample sizes are large enough to accommodate statistical tests to generalize beyond a population of 5,000 people.

In addition to sample sizes, we also reviewed sampling *strategies* to understand the techniques used in studies to obtain representativeness in their samples. Many papers did not explicitly articulate their sampling strategy. For instance, many survey studies simply stated that visitors participated in the survey, without specifying how those individuals were selected (e.g., based on time of day, season, etc.). Given these omissions, we attempted to infer sampling practices based on sample size and descriptions of participants. It appeared that most survey studies likely used a convenience sample, in which participants came from the groups easiest for researchers to reach. This sampling strategy makes it difficult to discern whether research findings can be generalized outside of that study.

The papers described a range of analytic approaches and techniques, which we reviewed to understand how museum projects came to their conclusions. Similar to the omissions we observed with sampling strategies, most papers in our dataset did not describe their analytic approaches. For those that offered this detail, papers from InformalScience.org and theses and dissertations were most likely to have thorough, well-reasoned explanations of their analytic approach. Analyses were most often described as either qualitative or quantitative, though a rare few triangulated between multiple types of data and analysis. A handful of studies appeared to use analyses that were inappropriate for their data. For instance, they used statistical tests on very small samples or reported proportions without identifying *N* values.

On the one hand, our analysis of choices about methods, sampling, and analytic approaches suggests that researchers in the museum field have invested in a rich exploration of the range of outcomes and institution-specific impacts produced by projects involving social issues and STEM. This approach seems to have enabled the field to experiment with and learn from a growing area of museum practice. On the other hand, our dataset has also demonstrated that these studies tend to omit discussions about the representativeness of the study population and groups deliberating on all of the sides of a social issue. Broadly speaking, this omission can complicate the generalizability of results. We acknowledge that small sample sizes are appropriate for particular projects, research questions, or the stages in a larger process of discovery. However, the field has few publications that contextualize the relationship between research participants and the broader population where the social issue in question is being debated.

Project Products

The project team used the analysis and findings to create the following products.

Publications

The Role of the ISL Field in Addressing Social Issues: A Matter of Capacity and Intention, by Kris Morrissey and Theresa Ball. This paper explains the theoretical framework for identifying social issues and how that shaped the inventory. We analyzed the inventory for which social issues were addressed by ISL organizations (and which were not), the impacts documented by these projects, the intended audiences for these projects, how the projects used STEM disciplines, and the infrastructure for projects at the intersection of social issues and STEM. As of the writing of this report, the paper was submitted to *Museums & Social Issues*.

Methods that Reveal and Conceal: What the Literature Says about Museums, STEM, & Social Issues, by John Fraser, Rebecca Joy Norlander, and Kathryn Nock. This article analyzes a subset of the inventory in which studies featured both an explicit focus on STEM and descriptions of the study's methods, which consisted of 110 papers. We reviewed these studies' methods to understand how the ISL field knows what it knows about social issues and STEM. We also reviewed sample sizes to gain insight into how these projects' findings can be generalized and made relevant to the broader ISL field. As of the writing of this report, the paper was submitted to *Visitor Studies*.

Museums and Social Issues: Heuristics and Professional Practice, by Kris Morrissey, John Fraser, and Theresa Ball. This paper examines how heuristics can be derived from the research synthesis accomplished through this grant. We offer six heuristics for applying the findings to museums' work on social issues. As of the writing of this report, the paper was submitted to *Museums and Society*.

Research Synthesis: Challenges and Opportunities of an Evolving Methodology, by Kris Morrissey. This paper reflected on Research Synthesis as a methodological approach, in particular as it pertains to the informal STEM learning field. The paper offers several principles that can guide research synthesis work, which leverage ethics, validity, practicality, replication, and relevance. This paper has been made available through several open repositories. DOI: 10.13140/RG.2.2.13810.63680/1

Museums, STEM, & Social Issues: An Ongoing Conversation, by Kris Morrissey, Theresa Ball, and John Fraser. This article explains the social issues addressed by ISL institutions, compared to other types of informal learning institutions. In particular, it explores trends for several social issues, including climate change, racial equality, COVID-19, and the economy. This paper was published in *Informal Learning Review*.
https://www.informalscience.org/museums-stem-social-issues-ongoing-conversation

Inventory & Data

We created an open access document that contains citations for the full inventory of 237 papers about museums and social issues. The resource also documents several categorizations that may be useful to researchers: the source of the document, the institutional environment in which the project took place, the document's purpose, and the types of methods involved in the study. The data can be viewed and downloaded from: https://bit.ly/2SoxBsk

Video

We developed a 3-minute video about the project and its findings for the 2021 STEM for All Showcase. This video can be found here: https://www.youtube.com/watch?v=WizndNT15aw and on The STEM for All Showcase website here: https://stemforall2021.videohall.com/presentations/2021

Posters & Conference Presentations

Preliminary results were shared in poster sessions at the American Alliance of Museums conference in 2020 and the Association of Science-Technology Centers in 2020:

Morrissey, K., Fraser, J., Norlander, R.J., Ball, T., & Flinner, K. (2020, May 21). *Poster: Addressing Societal Challenges through STEM*. Informal Science. https://www.informalscience.org/poster-addressing-societal-challenges-through-stem

Morrissey, K., Fraser, J., Norlander, R.J., Ball, T., & Flinner, K. (2020, May 31) *Addressing Societal Challenges through STEM ASTC Poster.* Informal Science. https://www.informalscience.org/addressing-societal-challenges-through-stem-astc-poster

Evaluation

The project's panel of advisors served an evaluative function for this research by reviewing the methods, data sources, conclusions, and implications. Project researchers met with and received input from advisors at several points over the course of the process.

In Year 1 of the project, over the course of five days in June and July 2020, the research team and advisors met in a video conference to review the development and organization of the inventory, emerging patterns in the data, potential conclusions, and recommendations for communicating the results. In these discussions, advisors reflected on the limitations of peer-reviewed literature as a source of data and emphasized the importance of clarity in articulating the selection and inclusion criteria used to build the inventory. They observed that the limitations would necessarily shape the inventory and therefore the research results. These limitations included the gaps between practice and research -- in other words, the projects that are described in peer-reviewed literature may differ from those that do not appear in the literature. They also noted the differences between institutions that receive funding to conduct and publish research, compared to museums that do not have access to these resources. The group discussed the ways that social issues shift in priority and valence over time, acknowledging the current events that were the focus of contemporary national conversations -- namely, the COVID-19 pandemic and the protests against racism. The detailed minutes from this series of meetings can be found in Appendix C.

In response to this input, the project team prioritized a detailed accounting of the procedures that were used to assemble the inventory, which are chronicled in the Methods section of this report. We hoped this work would enable other researchers to both replicate the research and expand this thread of inquiry. We also determined which paths of analysis the research team could accomplish and which analyses fell outside of the scope for this funding. In the Discussion section below, we call attention to the opportunities we could not pursue within the scope of this grant.

In Year 2 of the project, we shared drafts of the papers with the advisors, along with digital forms for feedback. Through the forms, we received feedback from three advisors on the paper titled "The Role of the ISL Field in Addressing Social Issues: A Matter of Capacity and Intention" (Morrissey and Ball, In Review) and one advisor on the second paper, called "Methods that Reveal and Conceal: What the Literature Says about Museums, STEM, & Social Issues" (Fraser, Norlander, & Nock, In Review) which informed our paper revisions. In May 2021, the research team had a virtual meeting with the two external reviewers to reflect on the project's products and implications. Here again, the reviewers advocated for clear documentation of the project's methods and procedures, suggesting that this information will be particularly valuable since the Literature Synthesis program category is relatively new. They remarked on the utility of the research products for the field, and recommended greater emphasis on explaining how audiences can use this work. The reviewers discussed at length the paper about methods and sample sizes (Fraser, Norlander, & Nock, In Review).

They leveled several concerns about the framing and recommendations of this study, including: the paper would benefit from a discussion of historical context of research in the field, there should be more clarity about research frameworks in addition to the focus on methods, and it should offer suggestions for museum research and evaluation, and how studies should specifically handle social issues. Finally, the reviewers commented on the ways this project can offer a precedent for literature synthesis research in the informal STEM learning field and promote dialogue on this type of research.

In response to the input for Year 2, the research team continued to refine the procedural descriptions. The PI produced an additional paper that explores the challenges and opportunities of research synthesis initiatives (Morrissey, In Preparation). This paper characterizes the essential qualities of this work: fair treatment of other people's research (ethics); a systematic analysis (validity); and an organized, concrete, and iterative data management approach (practicality and openness to replication). The researchers also undertook a substantial revision of the paper on methods and sample sizes in projects about social issues and STEM.

Discussion

The Addressing Societal Challenges through STEM project showed that the informal learning field cultivated a rich practice in developing exhibits, programming, and professional development at the intersection of social issues and STEM over the last 20 years. The literature on this topic offered ample evidence of experimentation with select social issues that rate highly as public priorities, several ways of integrating STEM disciplines, a number of areas of impact, ways of framing social issues, and efforts to build the infrastructure for this work.

Our research made clear that museums and other types of informal learning institutions have the potential to help their publics address the overlap of social issues and STEM topics in three distinct ways (Morrissey & Ball, Under Review). First, informal learning organizations have a *Role as Knowledge Brokers*. The public needs reliable information about social issues and STEM. Museums have excelled at supporting learning, and should continue to expand their repertoire to cover a broader set of social issues. Second, museums play a *Role as Advocate.* In particular, ISL organizations have increased their capacity to promote action around select social issues, such as climate change. But there are a wide range of other social issues and concepts -- like equity and justice -- that appear to remain rare in museum projects. Third, museums fill a *Role as Change Agent*. Museums have made gains in supporting individuals' actions and changes in behavior, but they have shied away from driving large scale, systemic changes to get at the heart of complex social issues.

Our analysis of methods used across the inventory gave us insight into how the field has learned from its experiments on social issues and STEM (Fraser, Norlander, & Nock, Under Review). We found that similar methods -- especially surveys and interviews -- were used across projects. We also observed trends in certain types of publications. Notably, publications posted in InformalScience.org tended to be more detailed in their explanation of their methods and were most likely to include mixed-methods approaches. Meanwhile, theses and dissertations typically offered robust descriptions of their rationale for selecting certain methods and theoretical frameworks. We also found that studies of projects about social issues and STEM focused on the distinct outcomes and contexts of their given interventions, and less so on comparing impacts identified in museum audiences to the broader community. As a result, we believe that there remains ample opportunity for the museum field to study and learn from its experiments with social issues and STEM.

This project gave us insight into the processes and potential for research syntheses as a methodological approach for the informal learning field (Morrissey, 2021). In 2017, the National Science Foundation added a new category of funding to its Advancing Informal Science Learning program. The "Literature Reviews, Syntheses, or Meta-analyses" category reflected researchers' interest in strengthening the knowledge base of a field that has long investigated learning impacts, but had relatively few opportunities to look across the cumulative work in this area. We started our project with the detailed methodological

approach outlined in our proposal, which hinged on a configurative literature review method. Like many research projects, we quickly saw our method challenged, compromised, and revised due to the nature of our data and scope of inquiry. In spite of the twists and turns in this journey, several principles guided our research. We propose that literature reviews and research syntheses should be conducted in ways that are:

1. Systematic: Protocols and strategies for searching, selecting, and analyzing literature should be systematic and transparent.
2. Pragmatic: A practical, organized, and flexible system for managing documents and processes is critical.
3. Fair: Claims and interpretations that are based on the work of other researchers should be fair.

Limitations & Caveats

From the outset of our project, we knew that our approach would necessarily constrain aspects of the research. We also surfaced several unexpected limitations. First and foremost, our research focused on publications about museum projects, rather than documenting museum practice itself. This means we may have missed trends and experimentation that did not appear in the literature. Due to our reliance on peer-reviewed literature, we recognized that the structures that determine what gets published and who publishes also shaped our findings. These structures include funders' priorities and requirements, publication and journal guidelines, institutional priorities, and university protocols for graduate work. Our scope specified a focus on US-based projects and institutions, which means that we likely missed emerging practices in other countries. Lastly, we anticipate that there have been and will continue to be a spate of museum projects exploring the COVID-19 pandemic and the anti-racism movement that came to the fore in 2020. On account of our search criteria for publications from 2000-2019 and the project schedule, we anticipate that further research will need to capture literature about this work.

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Appendices

Appendix A: Search Terms

Terms Generated by New York Researchers

Issues identified in opinion poll review (e.g. Pew Research Center, Cable News Network (CNN), The Washington Post, Gallup Poll, The Wall Street Journal, and The National Broadcasting Company (NBC), as well as reviewing transcripts of State of the Union addresses from 2015-2019.

Generated Search Terms

Abortion	Drugs	Voting
Immigration	Opioid	Political Reform
Crime	Workforce	Corruption
Climate change	Energy	War
Pollution	Incarceration	Terrorism
Inequality	Violence	Military
Poverty	Gun	Gender
Healthcare	Racism	
Human rights	Equality	

General Search Terms

Social Issues

Social challenge

Social Problem

Social Controversy

Equity

Inequity

LGBT

Terms Generated by Seattle Researchers:

Issues identified by three or more public opinion polls balanced by reviews of polls (Silver, 2018): Pew, CNN, CBS/NYT, Gallup, NBC/Wall Street, ABC/Washington Post, the Associated Press, NPR/Marist/PBS.

Consistently ranked high on lists of issues or problems

Climate Change

Education

Economy

Healthcare

Immigration

Crime

Terrorism, national security

Consistently on lists of concerns

Corporate Power

Federal budget & deficit

Race relations/Racism

Poverty/Hunger/Homelessness

LGBTQ rights

Advancement of Computers/Technology

Drug abuse

Gap between rich and poor

Gun violence/policy

Privacy

Gender disparity

Abortion

Taxes

Big Tech

Appendix B: Candidate Journal List for New York Researchers

Journal Title	ISSN	Country	Publisher
CRM: The Journal of Heritage Stewardship	1068-4999	USA	National Park Service
Curator: The Museum Journal	0011–3069	USA	Wiley-Blackwell
International Journal of Cultural Property	0940-7391	UK	Cambridge University Press
International Journal of Heritage Studies	1352-7258	UK	Routledge (Taylor and Francis)
Journal of Cultural Heritage	1296-2074	France	Elsevier
Journal of Heritage Tourism	1743-873X	UK	Routledge (Taylor and Francis)
Journal of Museum Education	1059-8650	USA	Left Coast Press
Journal of the American Institute for Conservation	0197-1360	USA	Routledge (Taylor and Francis)
Journal of the History of Collections	0954-6650	UK	Oxford University Press
Muse	0820–0165	Canada	Canadian Museum Association
Museum and Society	1479-8360	UK	University of Leicester
Museum Anthropology	0892-8339	USA	American Anthropological Association
Museum International	1350-0775	France	Wiley-Blackwell
Museum Management and Curatorship	0964-7775	UK	Routledge (Taylor and Francis)
Museums and Social Issues	2051-6193	USA	Routledge (Taylor and Francis)
Museums Journal	0027-416X	UK	Museums Association
Studies in Conservation	0039-3630	UK	Routledge (Taylor and Francis)
Tourism Review International	1943-4421	Australia	Ingenta
Visitor Studies	1934-7715	USA	Routledge (Taylor and Francis)

Appendix C: Meeting Minutes from Year 1 (2020) Advisory Call

Online Advisory Meeting

Date:	June 24, 25,30, July 1 & 2, 2020	Location:	**https://zoom.us/j/5563540087**
Time	3:00 – 5:00 Eastern, 2:00 – 4:00 Central, Noon - 2:00 Pacific	Project:	**Addressing Societal Challenges through STEM (ASCs): A Research Synthesis**

Attending:	Marjorie Bequette (reviewer) Kevin Crowley (reviewer) Tonya Matthews Joan La France Stephanie Ratcliffe Troy Sadler	Project # Grant # Project Team	IML499 1906556 Kris Morrissey, John Fraser Joanna Laursen Brucker, Terri Ball, Kate Flinner, Rebecca Norlander

Goals
- Our advisory meeting aimed to provide a range of perspectives and potential impacts of this work at the midpoint of the project, to suggest possible areas of inquiry for coding the assembled literature, and to develop concepts for dissemination that most closely map to the needs of the users of the project outputs.

Item	Description	Follow Up
1.1	**Day 1: Introduction to the ASC Team, Project, and Inventory** • Introductions • Collaborating on Zoom • Introduction to the ASC Project: purpose, research question, and theoretical foundations	
1.1.1	**Developing the Inventory** • Project team presented the working definition of social issue: Evidence of public claims that the topic is a social problem and warrants that the ISL field is/could/should address the problem • Morrissey presented the overview of the inventory (234 studies, 75 dissertations, 50 reports from informalscience.org, 109 articles from peer-reviewed journals) • Advisors discussed the boundaries set by the research and implications, particularly the exclusion of grey literature such as blogs and conference papers and focus on informal learning institutions (i.e. schools and afterschool programs excluded). • Advisors noted that the majority of the profession draws practice recommendations from the grey literature. The group discussed the issue of the representativeness of the peer-reviewed literature to the	Advisors recommended the final products, be clear about selection criteria and difficult decisions including exclusions.

	larger professional discourse. This topic was resolved at a later time in the workshop.	
1.1.2	**Roles & Responsibilities of the External Reviewers** (Discussion with Reviewers only) ● The team worked with reviewers to clarify role and responsibilities. Reviewers will provide oversight, particularly on the methods and conclusions of the ASC project.	Bequette and Crowley to provide review to support annual reporting and final report.
1.2	**Day 2: Organizing the Inventory** Project team presented: ● the approach to literature organized by environment (informal STEM, non-informal STEM), type of literature (peer-reviewed journal article, informalscience report, theses or dissertation), and purpose (expository, descriptive, empirical) ● Topics (heavy on climate change, racial inequities, incarceration, health, immigration) ● Differences between STEM-based institutions and non-STEM based institutions.	Team to focus on supplementing the core literature as it emerges in the process.
1.2.1	**Discussion** ● Advisors suggested that the team focus on how current events (Covid, BLM) might impact results of the project. The team noted that the research frame predated COVID-19 and the spring 2020 BLM uprising (but not the precursor issues related to BLM). ● Advisors deliberated on how power structures and impact on if/how/which issues are addressed in the literature, and the discordance possible between research conducted in and by museums, by graduate students, and by academic researchers, noting that permissions and right to publish are different in each condition. ● Advisors noted that social issues change over time and recommended the team consider how to address how these changes might be captured in our definition of social issue. ● The advisors revisited the discussion about what is published vs what is occurring in the field and what that might imply in the findings. The advisors recommended that the project team reflect the specific narrowness that the literature represents as one lens on museum practice.	Team will ensure the spring 2020 social conditions are reflected in reporting and note absence due to timing. Team will attend to how social issues change in priority and valence over the 20-year study frame. Team will be careful to ensure they state limitations clearly.
1.3	**Day 3: Identifying Trends** Project team presented ● That the findings suggest there is an Increased focus on social issues in field but still gaps.	

- STEM-based and non-STEM based institutions address different issues and audiences
- Theory of change: focused more on individual that societal or institutional level although social issues by definition are systemic;
- Science content in the data corpus seem to heavily represented, but technology, engineering, and math were seldom included in content that touches on social issues;
- Types of interventions in this data corpus were primarily exhibits but later publications seemed to expand breadth of strategies, particularly around dialogue and media.

1.3.1 Discussion

- The advisors were concerned or questioned how the role of funders and funding priorities might be evident in the data corpus, or whether that factor is evident as an influence on the types of social issues addressed and the work being published; - Are we missing certain types of museums, particularly small to medium (or are those addressed in theses) - Institutional change: Are institutions changing how they perceive themselves as they delve into social issues and community dialog? - Morrissey noted that we suspect there is a preliminary trend towards individual impact vs community/societal level change. The advisors discussed why this might be (evaluation and funders), and the implications to the research.	The team will determine if the data can address: funder influence, museum type, and institutional self-awareness. Team will attend to time of publication to reflect on the issue of museum self-perception

1.4 Day 4: Drawing Conclusions

- The team presented an overview of four exemplary projects that illustrate the trends being identified (or absence): Race Are We So Different exhibit and programming, Immigration NUEVOlution! Latinos and the New South exhibit & dialogue program, Provocative Questions at MOS exhibits and programs, Viruses, Vaccines & Public Understanding research project
- The team discussed four potential ASC paper topics that seemed to be emerging from the variation in the data, and the team's perception of their relevance to audience and how they respond to the research questions

1.4.1 Discussion

- The advisors asked the team to attend to how time of publication might the growing use of dialogue as an intervention; - The group deliberated on the issue of trust in museum authority and its impact on the success or failure of programs and in addressing social issues;	The team will ensure coding includes date of publication, and identify where

• The group deliberated on the limitations of literature represented in this study vs practice. The discussion gravitated toward recognizing that prevalence of a topic in the literature of boundary pushing programs and the lack of visibility of well-establish and more routine programs. A counter argument noted that some boundary-pushing work may not prioritize publication in the peer-reviewed literature because there is no merit/reward system for publication in most museums engaged in social issue engagement; • The advisors cautioned that there are privileges that flow from in-house evaluation teams and those privileges influence who/what is published; • The advisors asked the team to consider how to represent the relevance of topics and issues to local communities, versus national focus as one analytical approach.	trust emerges as a question. The team will note the limitations of the literature in this data corpus as a representation of the lived experience of museums. The team will attend to how location is represented in the data corpus.

1.5   Day 5: Communication, Storytelling, & Priorities

(We note that one advisor (LaFrance) had a challenge joining the meeting and provided feedback on the advisor discussion transcripts a few days following this meeting).

- The group reviewed parking lot topics that had emerged over the first four days. (audiences, types of institutions involved, power structures, rigor of research, small and rural museums)
- The discussion focused on prioritizing stories in relation to audiences, and potential platforms for sharing;
- The advisors offered individual recommendations on what might be overlooked or ideas to add.

1.5.1 Discussion • Advisors noted the role of collaboration (or lack thereof particularly between STEM and non-STEM based institutions) and the implications of that issue as data that may not be present, but could be discussed. • The advisors highlighted the value of graduate research to the field because it has different priorities and research traditions; • An advisor asked if the purpose of the work was to develop a research agenda (or identify research priorities)? The team stated that they were hesitant to draw this type of conclusion since the work is a configurative review and represents the limited bias and frames of the PI's rather than concerns that might need to be addressed by the field. The team will consider the degree to which this project might suggest paths for research and note absence in this data corpus may not represent a gap in practice research, only the literature's representation of that condition.	Final products should be accessible and useful. The team will work to reflect how to represent graduate literature. The team will revisit techniques

- The advisors deliberated on how the research outputs could be prioritized to support audiences (museum practitioner, funder, researchers). The advisors noted the over-saturation of webinars and online presentations in the current era, and recommended that the team revisit strategies to produce smaller, easier to consume assets that can be distributed without synchronous engagement.
- The advisors recommended customizing formats to specific audiences (blogs and case studies for practitioners, peer reviewed lit for researchers, small scale conferences/dialogues, infographics, teasers, or short squibs and video captures that could be shared via social media)

for presenting results and consider a more layered media dissemination strategy than our initial webinar concept.

Appendix D: Meeting Minutes from Year 2 (2021) Advisory Call

Online Advisory Meeting

Date:	May 4, 2021	Location:	**https://zoom.us/j/5563540087**
Time	1:00 – 3:00 pm Eastern, 12:00 – 2:00 Central, 10:00 - 12:00 Pacific	Project:	**Addressing Societal Challenges through STEM (ASCs): A Research Synthesis**
		Project #	IML499
		Grant #	1906556
Attending:	Marjorie Bequette (reviewer) Kevin Crowley (reviewer)	Project Team	Kris Morrissey , John Fraser Joanna Laursen Brucker, Kate Flinner, Uduak Grace Thomas

Goals
- This final meeting of the reviewers and the project team sought feedback on the quality and impacts of this work at the conclusion of the project.

Item	Description	Follow Up
2.1	**Updates on the Research** • The team summarized the project results and reviewed all deliverables shared in advance	
2.2	**Reviewer commentary on the overall work product** • This conversation focused primarily on the newest product, an article that critiqued the ability of the inventory to be used for a meta-analysis. • The reviewers started this discussion by commending the team on a thorough effort to synthesize the work. • A reviewer noted the importance of providing information on the literature synthesis process since it's a new NSF category in 2018 and the process can inform future synthesis grantees work for the field. This point was raised again later in the meeting. • Reviewers felt that each product stands alone, but were curious about the value of integration rather than cross-referencing. They raised a concern that the reference list itself was constrained by the research question, but noted that it may not be necessary to synthesize across the different projects. • One reviewer considered how each piece would be used by the field in a best case scenario. This led to a discussion of audiences, including: graduate students vs researchers vs busy museum workers. The reviewers agreed that there needs to be clarity about what these folks can learn from these resources.	Morrissey notes to issues of representation when we are speaking about others research Project final report to be structured to address audience value in exec summary

- A reviewer discussed how the work product might be received by a skeptic of the field. The concern focused on the great deal of information about what is not known and how that can be subjected to misuse or used maliciously to undermine the informal science field (see commentary on the article about research methods and sample sizes.
- A reviewer recommended more direct push-back on the paradigms promoted by Fu et al. (2015) and the post-positivist paradigm that does not conform to social action research.
- A reviewer revisited the commentary on the mid-project review, noting the limitations need to be more explicit in stating that practice is not well represented by the academic publishing repositories. They recommended that the final report characterizing the nature of the literature for academics and practitioners who are looking to use this work, noting the expansive nature of dissertations versus the purposeful evaluation that's rather narrow and utilitarian.

1.1.2 Peer-article review (Article on Research Methods & Sample Sizes)

- A reviewer appreciated that the project named the problem in the literature and brings clarity since the field is working with big aims and claims. That reviewer felt the choice to focus on methods was a good approach, but noted that the recommended approach is a solution that will likely provoke rigorous debate about whether it is the right approach.
- The reviewers felt this article could benefit from a short review of the history of the field and information on the knowledge transitions toward social issues. Specifically reflecting on the expansion of design-based research and community engagement work, they felt it is important to know why the authors think this is an important issue. That led to a suggestion that the paper have a stronger emphasis on the purpose of research and the author's voice in relation to that purpose. They suggested it may also be useful to revisit the three data sources to explicate the different purposes of research and their libraries.
- The reviewers felt that the paper, as presented, remains an incomplete story. They felt there is a need for more details about frameworks, hypotheses and commitments to research that make this work useful. In stating this, they noted that methodological approaches were heavily driven by the research aims, so it is difficult to draw conclusions from methods that don't conform to research aims. That discussion led to further clarifications to describe research to support improvement, design, change, risk – essentially, reasons for why we do the work and not just methods used for that work.
- A discussion arose around the concept of standardized measures as a recommendation. A reviewer noted that if we center the work in community, it should mean we do research differently and that may not mean generalization or standardization. It seems that a lens for the methods should focus on the community at the center, and that notion should be introduced into the paper. Generalizability might better be

Bequette and Crowley to provide written review to support annual reporting and final report.

Authors to revise paper to clarify principles of research versus methodological review

described as "relevance."

Fraser noted that this may be a misconception in the paper and will rectify the confusion. Fraser noted that the issue is not standardized "Measures" but rather, benchmarking the research population to what is known about public beliefs and attitudes (i.e., clarifying where an audience stands on a social issue in relation to the national debates, to avoid studies of the "choir"). In doing so, the reviewers felt the paper could be improved if it focused on creating an argument for why benchmarking to principles will produce aggregate value for practitioners. A reviewer then noted that an alternative approach would be to make clearer arguments for developing common language for talking about engagement.

- Further discussion of the above point suggested other framing, noting that researchers enter the field in different ways. And, that there is a need to talk about how the work that we are doing can be generalized.
- A reviewer suggested changing the title of the article: suggesting that social issues are different and you can't treat them like other museum issues.
- The reviewers felt the discussion could be improved if it reflected on how to write up museum studies in ways that are more broadly useful for the field. A suggestion in this vein suggested producing reports – synthesizing research – for the purpose of crafting a larger argument. In so doing, this paper could benefit by separating the discussion into who the audience would be for these reports.
- A reviewer suggested expanding the conclusion to talk about what it means to be a good evaluator and what commissioning organizations should expect in their relationship with an evaluator.

| 2.3 | **Review of the Work Products and Project Goals** | Research team to focus on supplementing the core literature as it emerges in the process. |

- Reviewers felt this and a few other funded projects were setting the norm for this funding mechanism.

- Reviewers felt the project fulfilled the terms of the grant proposal. They appreciated eliminating the previously planned webinars in response to the COVID-19 circumstances. They noted that the results were a high quality and productive project - with three papers being substantive output.

- The reviewers were curious about how the project met the goals of Broadening Participation, but noted that this is related to how the community appears in the research and how the community is centered in the work.

- The reviewers felt that (some) museums have been following what the public wants in their turn toward social issues. They noted that those museums are behaving differently and seeing themselves differently, so logically this result is present in the literature.

- Reviewers suggested that there is now sufficient material to support a fireside chat about conducting and communicating reviews in a way that benefits the field. The reviewers suggested this might be a relevant topic for

the CAISE PI meeting to facilitate a discussion of asking the questions in a different way.

- An advisor suggested that it may be worth pursuing a proposal to look at all the funded synthesis projects in this new category.

2.4 Implications and Impacts for the field

- A reviewer felt the project helped frame the fieldwide questions, but noted that we can't assume that putting good information in front of our community is going to change that community.

- A discussion did arise on the issue of quoting researchers writing and how that might decontextualize their thinking. Overall, the reviewers felt the authors were adhering to reasonable ethical practices.

- The group had a discussion about methodological approaches that are internally rigorous, but may not address the need for generalizability. In other words, the group felt that studies can be valuable without including large sample sizes that enable comparison with the general population. The point was considered a relevant learning from the project and the team was encouraged to reflect on this point in the final report.

- A member of the team suggested that other knowledge worlds might be similarly robust on this topic, such as Twitter and other social media forums where social issues, STEM, and museums are debated. All agreed this was an interesting next step beyond the scope of this project.

- Reviewers felt this project introduced the question of the kinds of topics that deep dives into literature could help. It raised the question of what criteria should drive these studies and why, so the field can pursue higher impact outcomes.

- A reviewer felt that museums see their role as more engaged with social issues in the past, noting that this is consistent with the findings. This provoked the question of whether change in practice shifts assumptions of what "generalizability" means to the field.

- Reviewers concluded by stating that the project added to what we know about engaging with social issues, as well as the value and processes of conducting a research synthesis. All agreed that the project raised as well as answered questions that will be important to share.

Team will attend to how social issues change in priority and valence over the 20-year study frame.

Team will be careful to ensure they state limitations clearly.

Team will address all of these points in the final NSF report and consider opportunities for future funding to pursue the next phase of this question.

Knology

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Knology.org
fax: 347-288-0999

tel: (442) 222-8814
3630 Ocean Ranch Blvd.
Oceanside, CA 92056

tel: (347) 766-3399
40 Exchange Pl. Suite 1403
New York, NY 10005