Advancing Community Science Literacy

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ABSTRACT

Addressing complex global issues – such as alterations in nutrient cycles, climate change, large-scale drought, widespread erosion, and new disease vectors – require adaptive changes in our collective behavior and policies. To date, approaches to advancing science literacy to address such challenges have generally failed to produce sufficient changes in behavior at the necessary scale. We suggest that past interventions have come up short due to a primary focus on individual change, rather than change that results that accrue in the small groups that are a basis for affiliation, social and cultural capital, and the domain where impacts tend to be replicated by others. Importantly, these are the same communities where scientific literacies are negotiated and grown. The authors illustrate the unique authority and social position that museums hold to activate such small groups toward solutions at a civic scale capable of matching scale of action to need.

Community science literacy

Our world has now entered the Anthropocene, an era where earth system processes are being radically altered by the human population acting at a global scale. Addressing complex planetary issues – such as alterations in nutrient cycles, climate change, large-scale drought, widespread erosion, catastrophic fire, and new global disease vectors – require adaptive changes in our collective behavior and the policies that foster these destructive behaviors. To date, approaches to advancing science literacy to address such challenges have generally failed to produce sufficient changes in behavior.

We suggest that past interventions have come up short because their focus has primarily been on individual choice rather than social change. This has been particularly true for the museum sector where funding and administrative fealty to government and industry tends to create a culture of acquiescence.[1]

The emergence of museums of conscience, museums for social justice, human rights museums, and memorial museums point to a shifting tide that bodes well for the use of material culture as a tool for thinking,[2] and in particular, how museums negotiate their role in the climate change issue.[3] As museum scholar David Carr notes, the museum and library sector are tools used for thinking.[4] Visitors, or *users* in Carr's terminology, arrive already far along in their learning journey, open to discovery and actively interested in their own growth. Because of this appetite for understanding, it is quite easy for museums to focus exclusively on the individual learner as the sole beneficiary of the museum enterprise. But museums have a unique role as beacons in their communities,

social actors whose choices and statements are followed carefully by their publics. Museums are not simply translators of knowledge, they serve as arbiters of value, wield authority, and confer privilege.[5]

We suggest that museums and the museum sector as a whole has the capacity to activate change at a civic scale, primarily because they are ideally situated as boundary organizations in their communities. The public holds positive stereotypes about museums based on their collections and management plans, uses that stereotype to confer authority, and acknowledges that these institutions are civic leaders charged with public education on those topics.[6] This is particularly true for zoos, aquariums, natural history museums, and science centers.[7] They are well positioned to engage purposefully with community groups, gather and activate entities within their region, and serve as trusted interpreters and advisors on how to act based on the implications of scientific findings that align to their mission.

We suggest that activation at scale is well within the purview of museums because the majority of social movements emanate from within a small, coherent and organized groups. This is best understood from the well-established diffusion of innovation theory developed by sociologist Everett Rogers, or network studies by Jierui Xie and his computer science colleagues that demonstrate that only 10% of a community is necessary to "tip" public opinion.[8] It is on this basis that we focus on how to drive social change through museum engagement by small concerned groups, or "tiny publics" that use museums. We use the term "tiny publics" based on sociologists Gary Fine and Brooke Harrington's definition of the "small groups that are a basis for affiliation, sources of social and cultural capital and a support point in which individuals in the group can have an impact on other groups or shape broader social discourse."[9]

Importantly, these are the same types of group affiliations that cognitive scientists Wolff-Michael Roth and Stuart Lee attribute to the context where scientific literacies are negotiated and grown.[10] As the National Academies Committee on Science Literacy and Public Perception of Science recognizes, "scientific literacy can be understood at both an individual and a community level" and

> science literacy in a community does not require each individual to attain a particular threshold of knowledge, skills, and abilities; rather, it is a matter of a community having sufficient shared resources that are distributed and organized in such a way that the varying abilities of community members work in concert to contribute to the community's overall well-being.[11]

We root our definition of community science literacy in the American Association for the Advancement of Science's conceptual framework as the range of literacies necessary for citizen decision-making by adults in a geographic area.[12] Following the work of science educators Morris Shamos and Larry Yore, we consider *basic science literacy* in the general population to consist of awareness that scientific information may be present and relevant.[13] We define *functional science literacy* as one's ability to converse, read, and write coherently in nontechnical contexts drawing on scientific findings, a community level necessity if groups are capable of acting to implement resilience strategies within their communities. In contrast to these two levels of literacy that we would seek to find across a general population, we characterize *operational science literacy* as the ability to use scientific ways of thinking to pursue solutions to problems. This last type

is important for those in leadership positions who can guide strategy and motivate shared solutions.

Science-based civic engagement

Science is often viewed as abstract and distant from daily life. Construal theory argues that this psychological "distance" (caused by spatial, temporal, social distance, and/or lack of certainty) can be a barrier to engagement and action.[14] Large-scale phenomena that are often understood through complex scientific instrumentation and mathematical modeling appear to be perceived as distant or outside the perceptual capacities of the majority of the population. Climate change, for example, is often seen as happening somewhere else, in the future, to someone else, and full of uncertainty.[15] Further, individuals and communities often lack a sense that they can meaningfully contribute to change.[16] These findings suggest that climate change communication should attempt to reduce perceived psychological distance by ensuring that climate change is "relevant to an individuals' social group, locality, and lifetime."[17]

It is important to benchmark this perceived distance against other similar phenomena such as financial planning where at least half the American public (with the capacity and financial liquidity to defer income in tax sheltered investments that could be used for retirement security) do not set aside funds for their future.[18] Furthermore, more than half the general public tend to have limited ability to plan for events, security, and contingencies beyond a six-month window, and insurance industries demonstrate that health insurance is anything but rational choice.[19] The evidence suggests that community level engagement in climate resilience strategies cannot assume that a general public has the capacity to independently manage their own risk, let alone imagine a meaningful role in community climate resilience.

We argue that a community-based approach that targets "tiny publics" is more likely to be successful since it can focus on concerns of value to the community; utilize scientific knowledge as a means to public ends; and involve deliberation, collaboration, and other forms of civic participation to work toward community-level solutions that are socially acceptable, feasible and effective.[20] This approach can create the conditions under which communities can participate in joint meaning-making, consistent with a "non-persuasive" approach that promotes understanding of causes and consequences rather than experts advocating particular policies or actions.[21]

The potential of ISLCs as changemakers

When we embarked on our work to develop the National Network for Ocean and Climate Change Interpretation (NNOCCI)[22] in 2009, we believed that informal science learning centers (ISLCs) had the potential to take on an expanded role as agents of change in their communities by capitalizing on their large reach, high degree of public trust, convening power, and science interpretation expertise.

The landmark National Research Council publication on informal science learning by Philip Bell and his science education colleagues suggests that ISLCs have focused primarily on the principle of outreach or serving as "third places" that can be forums for community dialogue.[23] We also reference historian Robert Archibald's book on the New Town Square,

now a rather dated publication but still relevant to the idea of a museum fostering or hosting community dialogue.[24] For example, the SCIENCES program at Chicago's Brookfield Zoo is exploring how to align programs to build environmental science literacy and community engagement. And, the Museum of Science, Boston, along with several other science museums, is exploring the role of public forums for deliberative dialogue. While this type of work is prevalent in the ISLC field, we believe it still falls short of the full potential for ISLCs to serve as community assets.

Bell et al. suggest that museums are capable of expanding their role beyond promoting public understanding to helping the public make use of knowledge that affects their lives, on topics such as climate change and nanotechnology. However, in the 10 years since publication this type of work has yet to reach its full potential in practice, and continues to be a subject that the National Academies seek to grow in their literature.[25] The Nanoscale Informal Science Education Network (NISE Net) project, for example, has addressed nanotechnology with a range of innovative formats including interactive experiences and deliberative forums, and has built an extensive network of participating museums. Extensive evaluation of NISE Net suggests that this project has had a significant impact on visitors' awareness, knowledge and interest, but does not address how the public has made *use* of this knowledge to address social issues.[26]

As museologist Kris Morrissey and co-authors state in their efforts on behalf of the NSF-funded Building Informal Science Education (BISE) project, their synthesis paper exploring a subset of the 457 publications posted on the Informal Science website suggests that ISLCs tend to avoid issues that do not have societal consensus, and continue to operate autonomously with their visiting publics and scholars, rather than playing a broader role in their community.[27]

Furthermore, the analysis by Morrissey and colleagues did not explore the role of cooperative authority sharing in addressing social needs, and found little evidence of museums and community organizations organizing and collaborating toward a common purpose.[28] In essence, we suggest that despite a variety of efforts to describe the cultural sector's engagement with community issues, the reports from the informal science field hinge on the idea of each ISLC working autonomously almost as if they are in competition with one another for public engagement.

Exploring the potential of informal science learning centers as social assets

Through several related projects, New England Aquarium (NEAq) and Knology[29] have been exploring how ISLCs can serve as social assets capable of catalyzing STEM literacies at a community scale, thereby contributing to building social capital and community resiliency. This experimentation has yielded some promising results, but also identified challenges that need to be addressed for this work to reach its full potential.

For example, the National Network for Ocean and Climate Change Interpretation (NNOCCI) brought together a group of ISLCs to address a key challenge in literacy and comprehension related to climate change. Through collaboration among informal educators, social scientists and climate scientists, NNOCCI developed common language, approaches and principles for communicating about climate change. By incorporating these evidence-based techniques into an in-depth training program, NNOCCI was able to build a network of more than 180 aquariums, zoos, and science/nature centers in 38

states. In turn, network members report training more than additional 38,000 informal science educators who are now reaching more than 150 million visitors each year, their colleagues in their community, and their social networks. By developing social support through a community of practice, the NNOCCI network has been able to sustain these coordinated efforts over time.[30]

NNOCCI has demonstrated the power of ISLCs working together for social change through public dialogue and engagement in climate solutions. It has shown how ISLCs can help to depoliticize science in ways that bring together economics and civic engagement with science learning. It also built a national network of emerging ISLC leaders eager to learn and adopt innovative techniques, which can provide a testbed for further experimentation. This work has motivated us to explore further engagement beyond the walls of the ISLC through purposeful community collaboration.

This approach reflects an intentional "turning outward" to move ISLCs from destinations to community catalysts.[31] In addition to building on NNOCCI's foundational work, this builds on techniques developed through a grant from the Bill & Melinda Gates Foundation to the American Library Association and the Harwood Institute for Public Innovation for *Libraries Transforming Communities* (LTC).[32] That project helped library professionals develop new skills and techniques for working as core community leaders and change agents around publicly identified community concerns – facilitating community conversations around needs and aspirations, fostering a positive culture of change, and engaging in collaborative action planning. Independent evaluation by Knology found the work both changed the view of library professionals and shifted national discourse within the library field and among the public toward positive perceptions of libraries for their community work. In addition, the evaluation demonstrated that these techniques were effective in increasing engagement and civic participation by community members who are often underrepresented in public process and reducing the likelihood of perceived or self-imposed exclusion.

In the most dramatic example, during the period when American cities were consumed by conflict between police and the Black Lives Matter movement, the Harwood Institute approach deployed in Hartford, CT created a community of practice that connected police with youth leaders in low-income public housing neighborhood. The only simmering protest to erupt in that community was defused by a police officer who was part of the program and understood the needs and concerns of youth in the area. That police officer recommended that all involved, police and protesters, turn the event into a dialogue and picnic for everyone to share their concerns. Effectively, what other cities saw as a conflict turned into a productive civic dialogue with increased understanding and positive action steps for reducing conflict with those traditionally underrepresented in public policy and policing.

A case study: communities advancing science literacy

Over the past two years, we have been exploring the application of strategic discourse and community change theory in two coastal cities. The *Communities Advancing Science Literacy* project (CASL) has been exploring a City Team approach in Boston, MA and Long Beach, CA to bring together ISLCs (NEAq and Aquarium of the Pacific) with community-based partners to facilitate conversations, planning and action related to community

aspirations, needs, and conditions. In the CASL pilot, we found that *communities' priorities to become more resilient underscored the intersection of social and environmental goals.* These included growing their sense of community, sharing power, and creating partnerships between multiple organizations/ groups. Our internal evaluation reports reveal that the two aquariums are increasingly being seen as trusted partners in building stronger communities through the collaborations they helped build, the conversations they inspired, and the resources they shared.

In Boston, those conversations helped partners align around shared responsibility for the future of the waterfront, and its critical role in strengthening social capital, climate preparedness, and environmental quality. Partners are inviting residents to co-create programs that build on community assets to engage and educate others. For example, the City Team hosted a three-day community event called Sounds of the Sea that engaged a cohort of youth in learning about local whale species, impacts of climate change, and how they can be protected. Activities included screening of the documentary film Sonic Seas, dinner and discussion at the ZUMIX recording studio with NEAq scientists, a whale watch and aquarium visit, and creation of a PSA for broadcast on the What's Up Eastie radio show to share what they learned.

Future work: capacity building and community organizing

This work demonstrates that there is pent-up and untapped potential for many ISLCs to increase their capacity to listen to community needs; find alignment with community goals and aspirations; identify opportunities for alignment with learning goals; and develop practical action strategies. Meanwhile, we have seen increased interest from ISLCs, particularly among aquariums and zoos, in finding ways to expand their civic engagement.[33] ISLCs (e.g. Virginia Aquarium, Aquarium of the Pacific, Science Museum of Minnesota) are being invited into conversations with city planners because of their valued role as science translators. The civic role of ISLCs has become an increasingly common topic at national conferences (e.g. North American Association for Environmental Education (NAAEE), Association of Zoos and Aquariums (AZA), and National Association of Interpreters (NAI)).

However, we have also identified a key challenge related to the capacity of ISLCs to play a "community organizing" role. The required mind-set and skill-set goes beyond that required in traditional partnerships between ILSCs and community organizations. Ultimately, this role requires the ISLC to *convene, align, facilitate, and organize the work of multiple organizations in pursuit of a common social purpose.* It involves negotiating the asymmetry and power dynamics between a large, well-resourced, visible ISLC and the smaller community partners it hopes to collaborate with as equals. As one of the City Team members in the CASL pilot commented: "The difference between community outreach and community engagement is that in the latter, both organizations change in the process."

We believe it is within the grasp of all museums to build on the principles uncovered through our work and those of our museum colleagues who are prioritizing their publics concerns as a core to their missions. We offer our efforts as one case where we have illustrated how to develop and test new models for capacity building that can be used to scale up a community-based approach to reach additional ISLCs, and ultimately to have a field-

wide impact. This multi-phased approach expands on what we have demonstrated with the successful NNOCCI model for communities of practice working to advance common literacy goals, and builds on three related bodies of work – *Community Science Literacy*, *Science-based Civic Engagement*, and *ISLCs as Changemakers* – described above.

To achieve the full potential for museums as community catalysts, we believe that ISLCs must not only rethink their role and missions, but also need to reposition their organizational capacity and culture in several key areas, including:

- *Effective communication* – Employing evidence-based communication techniques to depoliticize science in order to increase engagement and understanding among lifelong learners (addressing the needs of the 80% of the population that is beyond school age);
- *Community engagement* – Developing skills in convening, facilitating, active listening for community aspirations, needs and concerns; integrating public knowledge with expert knowledge; and identifying areas for alignment to a common purpose;
- *Community of practice scaffolding* – Fostering effective commitment to collaboration, reflection and evaluation across both staff and community partners; and
- *Community organizing* – Developing the specific internal skills required to support local leadership; and
- *Aligning the mission to community service*– Directing focus toward learning outcomes that can be achieved through collaboratives and groups of interested organizations rather than focusing solely on individual learners' growth as a measure of success.

While our research has benefitted from both our scale as institutions and our national funders, the model itself is really a shift in locus of control from a competitive to a collaborative model. The results of our research suggest that the repositioning we describe above is very much an issue of mindset and mission. We have shown that these professional development goals can help supplant the dominant assumption that museums compete for users' leisure time. Our repositioning of skills can go a long way to imagining all museums as collaborators first and foremost, support our community's self-directed growth through sharing our resources and skills.

Conclusion: broader impacts

We suggest that by applying techniques developed specifically for cultural institutions communicating about climate science (NNOCCI and CASL), and merging them with techniques developed for libraries and other organizations for working on meeting emergent concerns in communities, it is possible to redefine the role ISLCs can play in addressing challenging and contentious issues such as climate change on a meaningful scale.

The theory challenges ISLCs to see community purpose as a central mission, shifting the focus from providing outreach as a transactional service to serving as social actors working toward a common purpose with community partners. We suggest that techniques we are exploring, and the grounding theory on which it is based, constitute a transformative paradigm that can help informal STEM learning institutions move from a transactional learning model to a public engagement strategy, recognizing that literacies contribute to building social capital and community resiliency.

Notes

1. See Janes, *Museums in a Troubled World*, concerns, reiterated by Janes and Gratton, "Museums Confront the Climate Challenge,"; Sutton et al., "Museums and the Future of a Healthy World", and Worts, "Museums" discussed below.
2. Orange and Carter, "It's Time to Pause and Reflect," 259; Orloff, "Should Museums Change Our Mission," 33; Ostman, Zirulnik and McCullough Cosgrove, "Storytelling, Science, and Religion," 117.
3. Janes and Gratton, "Museums Confront the Climate Challenge," 97; Sutton et al., "Museums and the Future of a Healthy World," 151; Worts, "Museums," 209.
4. Carr, *A Place Not a Place*, 35.
5. Fraser, "Thinking About Museum Type," 264.
6. Fraser, "Rethinking Purpose and Capability," 523.
7. Rank et al., "Understanding Organizational Trust."
8. MacVaugh and Schiavone, "Limits to the Diffusion of Innovation," 197; Rogers, *Diffusion of Innovations*; Xie et al., "Social Consensus Through the Influence of Committed Minorities."
9. Fine and Harrington, "Tiny Publics," 341.
10. Roth and Lee, "Scientific Literacy as Collective Praxis," 33.
11. National Academies of Sciences, Engineering, and Medicine, *Science Literacy*, 73.
12. American Association for the Advancement of Science, *Benchmarks for Science Literacy*.
13. Shamos, *The Myth of Scientific Literacy*, 215; Yore, "Science Literacy for All," 5.
14. Trope and Liberman, "Construal-level Theory of Psychological Distance," 440.
15. Leiserowitz, Maibach and Roser-Renouf, "Global Warming's "Six Americas"," 1; Gifford et al., "Temporal Pessimism and Spatial Optimism," 1.
16. Norgard, *Living in Denial*, 1.
17. Spence, Poortinga and Pidgeon, "The Psychological Distance of Climate Change," 957.
18. Hacker, *The Great Risk Shift*, 114.
19. Handel and Kolstead, "Health Insurance for "Humans"," 2449.
20. Rudolph and Horibe, "What Do We Mean by Science Education," 805; Levine, *The Future of Democracy*, 13.
21. Fischhoff, "Nonpersuasive Communication About Matters," 7204.
22. The National Network for Ocean and Climate Change Interpretation (NNOCCI) is a network of more than 180 informal science centers (e.g. aquariums, zoos, and parks) in 38 states. NNOCCI provides in-depth training, called Study Circles, for informal science educators from aquariums, zoos, and science/nature centers across the U.S. NNOCCI teaches environmental educators at informal science centers to use strategic communication and framing techniques to educate and increase awareness on climate change challenges and encourage solutions through community level action. NNOCCI was funded during 2010–2018 by two grants from the National Science Foundation through the Climate Change Education Partnership Program (www.ccepalliance.org).
23. National Research Council, *Learning Science in Informal Environments*, 232.
24. Archibald, *The New Town Square*, 14.
25. National Academies of Sciences, Engineering, and Medicine, "Science Literacy," 73; *How People Learn II*, 227.
26. Bequette et al., "NISE Net Years 6–10 Evaluation Summary," 65.
27. Morrissey et al., "Museums & Social Issues," 1.
28. Dr Kris Morrissey is a Research Fellow at Knology and agreed with this assessment of the work she led with her colleagues.
29. Knology, a non-profit think tank was originally incorporated under the name New Knowledge Organization Ltd.
30. Geiger, Swim and Fraser, "Creating a Climate for Change," 104; Geiger et al., "Catalyzing Public Engagement with Climate Change," 221.
31. See the work of the Harwood Institute for Public Innovation, https://theharwoodinstitute.org/practice.

32. Flinner et al., *Final Evaluation Report*, 50.
33. See for example, Simon, *The Art of Relevance*.

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