Making Science Matter: Collaborations Between Informal Science Education Organizations and Schools

A CAISE Inquiry Group Report

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Executive Summary

Introduction

Throughout the world, and for many decades, science-rich cultural institutions, such as zoos, aquaria, museums, and others, have collaborated with schools to provide students, teachers and families with opportunities to expand their experiences and understanding of science. A recent study (Phillips, Finkelstein, & Wever-Frerichs, 2007) found that more than 70% of science-rich cultural institutions in the United States have programs specifically designed for school audiences. These programs include supplementary classroom experiences; integrated core academic curricula; student science learning communities located in afterschool, summer, and weekend programs; teacher professional development programs and communities; and even district infrastructure efforts around issues such as standards and assessment development or teacher preparation.

These collaborations have allowed students, and also teachers, to explore, understand, and care about a wide range of natural settings, phenomena, and cultural and historical objects. They have helped students to notice, consider, and investigate relationships between human social behavior and environmental consequences. They have provided contexts, materials, rationales, and support for students and teachers to engage deeply in scientific inquiry processes of learning. These experiences—with an array of real-life settings, animals, professional science communities, objects, scientific instrumentation, and current research and data—have been shown to spark curiosity, generate questions, and lead to a depth of understanding and commitment in ways that are often less possible when the same material is encountered in books or on screens.

But despite scores of such examples, these collaborations have generally failed to institutionalize: in many communities they come and go with changes in funding or leadership. There are many reasons for this pattern, both global and local. Global reasons relate to the hybrid nature of formal-informal collaborations which make them fall outside of obvious funding categories, render standard assessment tools inadequate to document their effects, and challenge priorities for both formal and informal institutions, since this work appears to fall outside of the core activities of each institutional type. Local reasons include changes in leadership or immediate priorities.

This report begins with the premise that it is important for us to move beyond these challenges. We draw on theoretical perspectives as well as practical examples to show that, in fact, formal-informal collaborations fall *exactly within the core activities* of both schools and informal learning organizations, including museums, youth programs, and libraries. But we do not argue, simply, for *more* collaborations. Rather, we argue for more intentional and strategic deployments of resources, leading to collaborations that build on the particular affordances and strengths of different institutional types to meet shared goals of making science learning more accessible and compelling to young people in our communities.

This Report

This report does three things that we hope will advance discussion about the value and nature of formal-informal collaborations:

1) Provides a rationale and theoretical basis for why the ISE and K–12 fields should care about and pursue such collaborations.

2) Reviews examples of such collaborations, noting their documented outcomes, and identifying emergent themes or characteristics.
3) Identifies existing trends, gaps, and questions that would benefit from further experiments in both research and practice.

Formal-informal collaborations are defined in this report as taking place among **K–12 schools** (and the supportive infrastructure including schools of education or district and state education offices), and informal learning organizations which include (a) **informal education organizations** (such as libraries, afterschool and youth programs) and/or (b) **science-rich cultural institutions** (such as museums, zoos, nature centers, and aquaria).

Rationale

Over the past decade, consensus in research, policy, and education communities has begun to emerge around three crucial understandings that pertain directly to the value and importance of formal-informal collaborations as well as to informal science education itself. These are:

1) Scientific literacy is more than factual recall; it involves a rich array of conceptual understanding, ways of thinking, capacities to use scientific knowledge for personal and social purposes, and an understanding of the meaning and relevance of science to everyday life (American Association for the Advancement of Science, 1993; National Academies of Sciences Committee on Science Learning K–8, 2007).
2) Learning, and the development of a sustained commitment to a discipline, develops over multiple settings and timeframes (Bransford et al., 2006; National Research Council, 2000, 2009).
3) Science education, as it is traditionally constituted, fails to engage and include a significant portion of society; most notably, women and people from high-poverty and non-dominant communities are underrepresented in science professional, academic, and organized leisure-time activities (Barton & Yang, 2000; Eisenhart, Finkel, & Marion, 1996; Nasir, Rosebery, Warren, & Lee, 2006).

These consensus understandings have direct implications for formal-informal collaborations. First, because the emerging vision of scientific literacy is complex, no single institution, such as schools, afterschool or youth organizations, or science-rich cultural institutions, can achieve this vision acting alone. It will take a combination of resources, expertise, timeframes, and learning designs to support and expand science literacy in today's world. Second, if we understand that children learn through multiple, varied, independent, and inter-dependent experiences across time and settings, it is incumbent upon educational designers and leaders (both formal and informal) to provide experiences that leverage prior and future experiences, and help to build coherence and meaning, across settings, around critical ideas and understandings in science. Third, schools serve diverse socioeconomic and cultural populations. But schools that serve high-poverty communities tend to be under-resourced, text-based, and test-driven (Harvard Civil Rights Project, 2006; Nasir et al., 2006); as such, despite dedicated teaching, these schools have limited capacity to support the development of rich science literacies. At the same time, science-rich cultural institutions, while excelling in ways to make science compelling, are less likely to work with children from under-represented communities. Formal-informal collaborations bring both the audiences and the opportunities together.

Theoretical Perspectives

The recent NRC volume *Learning Science in Informal Environments* (2009) stresses the utility of sociocultural theories of learning for guiding program designs and evaluations in informal as well as formal settings. Sociocultural perspectives suggest the importance of establishing authentic goals or purposes that provide students a meaningful context in which they can build on their skills, strengths, and interests to participate in and contribute to valued activities (Bronfenbrenner, 1979; Eisenhart et al., 1996; Rogoff, 2003; Stetsenko & Arievitch, 2004). Learning activities are organized such that they require participants to take up and use the cultural tools of science in order to achieve their goals. In this view, people learn to use the tools of science (such as thermometers, telescopes, formulae, scientific argumentation, modeling, and others) because they are the best available means for answering questions or achieving purposes that matter to them. In this sense, powerful learning activities are designed to be "authentic" both in terms of establishing real purposes for undertaking them, and in introducing the tools of science as the best available means for successfully achieving one's purpose (which is also why they were developed historically: to achieve real purposes such as building bridges or navigating under the night skies).

Sociocultural perspectives also stress the critical role of the adult (or more capable peer or supportive community) in helping learners to create or find purpose. As such, they underscore the importance of designing and facilitating activities that can both inspire *and* sustain participation by welcoming in, supporting, and gradually increasing the complexity or sophistication (the "conceptual depth") of the goals, tool-use, and activities with which participants engage (Bronfenbrenner, 1979; Lave & Wenger, 1991). People forge their developing selves (or identities) through active participation in such authentic, accessible, and conceptually rich activities (Holland, Lachicotte Jr., Skinner, & Cain, 1998; Lemke, 2001).

While such perspectives help to build a vision of powerful learning designs, understanding why and how collaborations among formal and informal organizations can achieve such a vision requires an analysis of the particular properties and affordances of the different learning environments. Our report details both the structural and the social properties of formal and informal settings, and later applies this analytical lens to exemplary collaborations.

For example, **structural properties** of K–12 schools afford the time, sequencing, and consistency necessary for learners to systematically develop the foundations for deep conceptual understanding. Such foundations may be necessary for learners to become seriously engaged in the subject matter, including pursuing advanced coursework and science careers. At the same time, schools are structured around primarily verbal or textual engagement with subject matter, and often present concepts in ways disconnected from everyday concerns of students. The structural properties of science-rich cultural organizations, on the other hand, include tactile, kinesthetic, and three-dimensional exhibits, objects and experiences that may afford different kinds of engagement and even understanding than can be developed in schools. Because most informal settings must design for general audiences, they may also be more accessible to greater ranges of prior knowledge and experience. At the same time, such settings are usually not accessed in systematic or regular ways; the episodic nature of their use may be a barrier to developing systematic understanding of specific concepts and how they relate to one another.

The **social properties** of informal settings include low-stakes environments, group or collaborative learning, and levels of flexibility that may afford learners' greater use of imagination and taking of risks. They allow learners to work at their own pace, following and developing their own interests. In schools, social properties

include year-long relationships between teachers and students that may be critical to teaching and learning, including expectations for engagement, and instruction that can take into account knowledge of the individual learner that is come to be understood over time.

Thus an affordance analysis suggests that it is more than objects or collections that formal-informal collaborations bring to K–12 science education, but rather potentially a more accessible, contextualized, and meaningful *approach* to the material. Such collaborations can be designed to draw upon

- The ways in which informal learning environments support direct, multi-modal experiences with multi-faceted portrayals of science, presented within their cultural context, and using authentic objects and phenomena.
- The ways in which school contexts can provide the sustained time, and developmental and pedagogical expertise, to build increasingly complex understandings of science phenomena and processes.

Program Examples

Our report identifies a wide range of formal-informal collaborations in five general areas: supplementary classroom experiences; integrated core academic curricula; student science learning communities; teacher professional development programs and communities; and district infrastructure efforts. The actual nature of these collaborations differs, based on the local needs and resources.

Most obviously, collaborations can differ in terms of the content area, reflecting the particular collections or resources of the science rich cultural institution, and particular content foci of the schools. Some programs are designed primarily for students, others for teachers. Formal-informal collaborations also differ along the dimensions of *time* (including both frequency and duration) and *structure* (meaning the extent to which activities are scripted, sequenced, and assessed). The less time and structure, the more the collaboration may resemble typical audience patterns at informal learning institutions: the drop-in visitor who arrives with their own agenda and spends as much time as they wish on whichever materials, exhibits, or activities that they choose. At the other extreme, at the time-intensive, highly-structured collaboration, programs may begin to resemble school-like patterns of activity, often in the tradition of learner-centered, constructivist classroom teaching and learning.

Our report spotlights three programs in each of the five collaboration types. All of these examples had collected evidence of their impact on participants. These programs may represent just the tip of the iceberg in terms of the number and types of formal-informal collaborations one finds around the globe. However, they represent virtually the entirety of the collaborative programs that we located with documented impacts on participants (and we defined impacts quite broadly, as readers will find). Despite their small number, the data collected by these exemplary programs suggest that formal-informal collaborations can be designed to contribute towards:

- Advancing students' conceptual understanding in science.
- Improving students' school achievement and attainment.
- Strengthening students' positive dispositions towards science.
- Advancing teachers' conceptual understanding in science.
- Supporting teachers' integration of inquiry and new materials in the classroom.

Emergent Themes

Our analysis of the properties and structural and social affordances of collaborations found five recurrent themes running through the programs:

1) Formal-informal collaborations can lead to conceptually rich and compelling science learning programs that build on the structural and social affordances of informal settings and objects.
2) Formal-informal collaborations can lead to the creation of learning communities that develop practices, dispositions, and understandings that valued across multiple institutional settings and boundaries.
3) Formal-informal collaborations can create more equity and access for children, and teachers of children, from high-poverty communities.
4) There is a lack of strong, valid, and meaningful evidence of the impacts of formal-informal collaborations, largely due to the lack of a well-theorized methodology that captures and describes impacts that have valence with both formal and informal stakeholders.
5) Formal-informal collaborations take significant time and energy, often unacknowledged by sponsors of the work, and are a continuing but valuable process of evolution for individuals and institutions.

These themes are not conclusive findings, but preliminary observations, all of which need to be subjected to more rigorous experimentation and research.

Recommendations

The Inquiry Group's review of the material, informed by both theory and impact data, led us to close the report with five recommendations to the field:

1) Expanding the research base. There is a need for more studies of existing and robust programs, including studies that address the different issues raised in the report, and studies that take a systems perspective to understand how learning in formal or informal settings affects the other.
2) Addressing funding barriers. There is a need for more funding for formal-informal collaborations. Many current funding agencies have difficulty knowing how to classify these hybrid programs, and as a consequence they oftentimes fall between the cracks of funding categories. Funders need to look to the goals of the projects (enhanced teenage understanding of science, or improved teaching practices, for example) rather than the mode. The mode of work is what needs expansion and experimentation. In peer review panels, this means that panelists must be selected who have an understanding of both formal and informal environments.
3) Expanding professional development for informal educators who work with formal audiences. There is a need for more professional development for informal educators that addresses the nature of work with schools and teachers, including school policies, assessment policies and trends, theories of learning, program design and evaluation. More teacher preparation programs should include introductions to informal learning institutions, resources, pedagogies, and people.
4) Expanding systems perspectives and programs. There is a need for more program experiments that test models of systems integration, for example, testing how afterschool settings can serve as teacher development sites, or for graduate training for future behavioral scientists, or for science-rich cultural institutions providing science pedagogical leadership in afterschool or youth settings, or for the co-development of K–12 science curriculum and activities.

5) Institutionally valuing formal-informal collaborations, and the expertise required to advance them. In the end, there is a need for greater understanding and support within science-rich cultural institutions for work with schools. Too often schools and teachers are seen as a "market" for field trips or other paid programs, rather than as a stakeholder audience. The extent to which science-rich cultural institutions conceptualize themselves as educative rather than entertainment organizations will be reflected in the depth of their collaborations with K–12 schools. A part of being deeply committed to science education must involve working with the more diverse populations of science learners that exist in local public schools and engaging their families in the life of cultural institutions.

In conclusion, our report finds that there is a great deal of work already happening in formal-informal collaborations. Many people and places are pioneering new ideas and approaches, some of which were included in this report. Many are increasingly concerned with documenting the results of these collaborations in meaningful and useful ways. We argue in this report that so long as public opinion polls continue to find that the public, especially the public from communities underrepresented in the sciences, characterizes science as alien, boring, overly difficult, or not directly relevant to their lives, we must increase our efforts in formal-informal collaborations to reach the greatest number of people, in the most compelling ways, for the most sustained amounts of time, in ways that can be achieved at scale.