

Broadening the View:

First Steps Toward Mapping the National Landscape of Out-of-School-Time Science Education

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Presented at *Inciting the Social Imagination: Education Research for the Public Good*, Annual Meeting of the American Educational Research Association, New Orleans, LA, April 8-12, 2011

Objectives

Informal learning experiences are significant contributors to how young people learn and develop interest in science, technology, engineering and math (STEM) (Bell, et al., 2009; Stockmayer, Rennie & Gilbert, 2010). Out-of-school time (OST) programs may offer significant learning opportunities for youth, especially traditionally underrepresented youth, to engage with science in meaningful, personalized ways that are not available within the context of school-based science education. Such experiences, it is often claimed, encourage students to pursue further education and jobs in science-related fields, thus influencing the quantity, quality and diversity of the workforce in STEM fields (e.g. Congressional Commission, 2000; Friedman & James, 2007).

Significant national investment also suggests the presumed value of informal education; millions of dollars are spent annually by private and public sources on programs offered after school, on weekends and during summers. Over six million young people participate in afterschool programs alone (Afterschool Alliance, 2004). Many of these afterschool programs offer some STEM-related activities but, due to the diversity of program types, the frequency and characteristics of these activities are difficult to determine (Chi, Freeman & Lee, 2008). Although some studies of OST science education programs have been undertaken, most of these have examined only individual programs (Barab & Hay, 2001; Richmond & Kurth, 1999; Stake & Mares, 2001, 2005.) Other studies have explored science programming in typical afterschool programs but say little about science-focused programs specifically (Noam et al., 2010). Even less is known about the national scope or reach of youth programming in science-specific OST venues such as museums, science centers, national labs or zoos.

Thus our research questions are:

How can we describe the landscape of U.S. science-focused OST programming?

How do program offerings vary by activities, populations served, duration and frequency, desired outcomes, and other key factors?

What patterns in these variables help to characterize current program offerings and define areas of future opportunity?

We have undertaken a mapping study to both broadly and rigorously describe the contexts, characteristics and practices of a diverse national sample of science-focused OST programs for middle- and high school-aged youth. We aim to develop a typology of programs delineating crucial features that differentiate such offerings, and to lay the groundwork for future study of exemplar programs in various categories.

As one tool in this study, we are developing a comprehensive database of science-focused OST offerings nationwide. Because programming at this level does not tend to differentiate strongly between different STEM disciplines, we will use *science* or *science-focused* throughout this paper to refer broadly to any STEM-related offering, including those that are primarily engineering or technology focused. By organizing findings from numerous sources into a common format and by gathering data on hundreds of youth science offerings, this relational database will be a powerful tool for analysis, allowing us to examine the diversity of OST science offerings and to search for patterns across many variables.

We are also developing an instrument that will allow educators to submit information about their OST science offerings directly to the database, thereby broadening the scope of offerings that we can study. Meanwhile, through in-depth interviews with well-placed informants and our broad-based observations of the OST science field as a whole, we are beginning to develop a birds-eye-view of an emerging culture of informal science education, as well as a more detailed understanding of the actual activities and practices in the field. Our typology of offerings should provide a clear picture of the landscape that may inform future investigations into community norms, values, goals and strategies.

Theoretical Framework

We approach the field of OST science education through a framework rooted in sociocultural perspectives on learning (Bell et al., 2009). We seek to understand individual learners in the context of their cultural and social environments, with a focus on learners' identities, values and beliefs, the development of their interests and motives, and the acquisition of skills and practices that locate them within particular cultures, including the culture of professional science. This approach is particularly appropriate because many informal learning programs place stronger emphasis on cultural and community values, learners' identity, and lifespan development than is typically found in formal schooling.

In sociocultural theories of learning, learning occurs through ongoing participation in a community of practice, or a group of people engaged in collective learning through a joint enterprise, such as a group of youth working together to solve a problem or build something (Wenger, 1998). Learners, who are "newcomers" to the community of practice, eventually gain mastery of the knowledge, skills, and practices of the community. With the guidance of more knowledgeable adults or peers, youth move toward greater responsibility and challenge. Some OST science offerings such as science career ladders typify this model of scaffolded

responsibility and engagement. As youth progress up the ladder they undertake more challenging tasks and engage with science and/or educational content at a more advanced level.

In order to apply this sociocultural framework at the program offering level, we include variables in our database that highlight individual youth experience – e.g. frequency and duration of participation and the nature of science activities in which they participate. Other variables address the youth and community populations served, and the degree of connection between student learners, their local communities, and the scientific community at large. We pay particular attention to the importance and impact of student engagement in communities of practice and their identity development through these experiences.

Methods

We use a mixed-methods design incorporating open-ended, semi-structured interviews with program directors, evaluators, researchers and other well-placed observers of OST science programs; analysis of descriptive documents such as brochures, evaluation reports and program websites; and analysis of quantifiable elements such as program longevity and student audience demographics. We refer to this approach as “mapping” because it draws on multiple types of data and combines them to form a broad portrait of this educational domain.

We began by mapping OST science education programs using an iterative, inductive method. We used preliminary data to refine study parameters and then applied these parameters to select further sites for study. Opportunities for OST science education are extremely wide-spread and varied; and there is a range of viewpoints among practitioners about what “counts” as science education and about what “counts” as out-of-school time. However, because communication between program providers tends to cluster within institutional sub-groups, there exists very little shared vocabulary with which to describe the field as a whole. Thus, it was important for us to create some preliminary categories and delineate several bounding variables from the outset in order to capture a sample that we could analyze for patterns and make inferences about. This lack of common definitions across the field points, itself, to a need for the kind of broad descriptive overview provided by a study such as this one.

In drawing our sample, we set bounds on the nature of offerings to be included based on several key definitions: First, we use the term *offering* to mean a science enrichment effort for youth that is conducted wholly during a time period or time periods when students are not formally attending school. This includes afterschool offerings delivered in small daily doses, multi-week summer camps, science-related work programs, Saturday workshop series and other formats. Because we are concerned with situated learning and student identity development within the context of a community of practice, an *offering* also refers to an educational opportunity that

occurs in a group or team setting¹. We did not include independent OST activities such as essay competitions, science fairs, one-on-one mentorship programs or tutoring in our sample.

Second, the study focuses on offerings targeting students from middle and high school grades. Children aged 6-12 report strong interest and confidence in their science abilities, but this drops off by age 14 (U.S. Department of Education, 2000). It is important to understand informal science offerings designed for students on this cusp and follow this particular leak in the pipeline. We include any offering that is open to rising 6th graders and older, up to the summer following high school graduation. Some offerings define their youth audience by grade and others by age, thus we also including offerings targeting youth aged 12-18.

Third, because we are interested in the student outcomes that educators have observed over time, we include only offerings that have been established for more than one calendar year. Our preliminary interview findings suggest that it takes time, often years, for programs to firmly establish their infrastructure, curriculum, activities, and audience; thus offerings that have been in existence for less than a year are not likely to have a well-defined, sustainable model yet or information about student outcomes. For the same reason, we limit our sample to offerings that persist with the same group of students over time, rather than single-session classes or short-lived workshops. We do, however, generously define “extended” learning opportunities as offerings that meet two or more times.

Finally, in keeping with the main thrust of our research questions and our interest in science-related student outcomes, we include OST offerings that self-define as *science-focused*, *science-rich*, or describe themselves as being centered around science or STEM. As mentioned earlier, what is typically considered science, particularly at the middle-school level, is often not discriminated by discipline; many of these offerings also include mathematics, computing and engineering activities and may also involve reading, writing, public speaking, or the arts. Because there is no universal agreement on what “counts” as a science-focused offering, we largely trust providers’ descriptions of what is important to them. Some other observable indicators common to science-focused offerings are time spent on specific science content, involvement of science or science education-trained staff, mentorship by professional scientists, the inclusion of inquiry in science activities or design elements in engineering activities, and affiliation with an established scientific organization such as a museum or national laboratory. Most science-focused offerings will include some combination of these factors or others not listed. We look at each offering on a case-by-case basis and, especially in this preliminary data collection stage, we tend to err more on the side of inclusivity with this variable than any other.

Our sampling methods begin with literature and internet searches for references to appropriate programs. We also rely on existing networks and professional organizations of informal science offerings. As we continually identify science-focused youth OST programs that meet our

¹ One area that we have not included in the current mapping work but that we consider a promising site for possible future study is OST science education that takes place in digital communities. One area for future study is to compare and contrast ways that group learning online compares to or augments collaborative learning in person.

sampling criteria, we select a subset of well-established, exemplar programs for interviews with program leaders. These interviews explore the programmatic and sociocultural elements that interviewees view as critical to learning, address informational gaps that cannot be filled from other materials, and identify student outcomes (both observed and desired). The interviews also employ snowball sampling (Patton, 1987), in which we ask interviewees to suggest other sites or program offerings, comparison groups, and other potential interviewees.

From these combined sources, data are recorded for each program offering in a relational database so that they can be organized, sorted and analyzed across multiple criteria. We then use this database to look at patterns and groupings and to develop a typology of programs. The typology's categories are determined both inductively, emerging from the data itself, and deductively, generated from our conceptual framework and research questions. Interview data are analyzed using domain analysis (Spradley, 1980) in which transcripts are searched for units of meaning. Groups of codes that cluster around particular themes are assigned to domains. Taxonomies are constructed linking domains to coded examples. Componential tables add a dimension of comparison across domains and data sets.

Data Sources

Data collection in this large mapping study is ongoing. Interviews were begun in Spring 2010. We initially invited 68 people associated with the field of OST science education to participate in a telephone interview; 40 accepted for a response rate of 59%. To date, we have completed 34 interviews (individual and group) with a total of 42 participants, including program directors, resource providers, researchers and evaluators. Digitally recorded interviews lasted 30-80 minutes. Respondents, most of whom have been involved with a particular institution or OST offering, told us about the goals and objectives of their programs, their target audience and the demographic makeup of their student population, outcomes they had observed among participants, and described in detail the kinds of science content and "hands-on" activities in which students engaged. Some respondents also talked about staffing, funding, resources, infrastructure, evaluation, and their offerings' relationships to the broader world of professional science, and provided valuable perspectives on the larger field of OST science education. We plan to continue interviewing and hope to have recorded a total of 60-75 in-depth interviews by Fall 2011.

Meanwhile, the collection of organizational and program offering details for the database is ongoing. Currently, we have collected over 500 offerings provided by close to 300 organizations from our own internet and literature searches, information collected at informal education-oriented conferences, snowball sampling through suggestions from interview participants and other well-placed informants in the OST science education community, and comprehensive reviews of the membership lists of a number of extensive professional networks including: Association of Science-Technology Centers (ASTC), National Girls Collaborative Project, Coalition for Science Afterschool, Association of Zoos and Aquariums, and the list of United

States National Laboratories. In addition to the relational database of offerings that fall within our stated sample, we are also compiling several smaller datasets listing, for example, national, state and independent organizations that provide funding, materials, professional development or networking assistance to OST science educators; key players in the emerging field of OST science education at the state and national levels; and particularly interesting offerings that meet several but not all of our sampling criteria, such as many purely math-focused programs and some offerings for younger children. Each of these data sources contributes something to building, bounding, describing and defining a map of the middle and high school OST science education landscape.

Results

The typology we create will delineate a key set of indicators that allow us to categorize the field in meaningful ways and to distinguish important factors around which youth OST science offerings are organized. Further interviews will provide insight into the strengths and weaknesses of different program types in achieving distinct goals and reaching diverse student audiences. Based on the data collection and analysis we have completed so far, we have begun to identify a number of significant variables among offerings. These indicators describe the field as it is; they are not meant to suggest that this is necessarily the optimal way for practitioners and stakeholders to organize youth offerings. In fact, having a clear snapshot of the field as it currently exists may illustrate some important absences and opportunities for collaboration and growth. Important themes emerging from the detailed information collected in our database and from interviews with OST science stakeholders include:

- *Program Offering Structure*

While OST science providers tend to cluster themselves by institutional provider type (i.e. afterschool program, aquarium or zoo, museum, science center), this variable defines offerings based on the specifics of *students'* day-to-day experience and is determined by factors such as time-frame, location, and activity content. For example, we differentiate between a brief but intensive summer field experience, a weekly astronomy club meeting, and a multi-year integrated mentorship program. Likewise, programs have different settings: activities may take place at a community center or camp, at a museum or science center, or in the field at a paleontological dig or a local watershed, or some combination of settings. By focusing on individual student experience within the context of OST science learning environments, we aim to develop an understanding of the sociocultural elements influencing different types of youth outcomes. We also hope to draw connections between similar types of offerings that may have useful experiences or tools to share but be unaware of each other due to their respective locations in disparate sectors of the OST science education landscape.

Program offerings are structured in a wide variety of ways, but there are several common models that we have noticed. Many science institutions such as museums, zoos and STEM departments

at universities offer one- or two-week summer camps, often focused on a specific topic such as robotics or forensic science. During the school year, there are numerous science-focused afterschool clubs that meet weekly, sometimes in classrooms at local schools. Some of these clubs are instances of larger national organizations that provide materials and organizational assistance to the local club organizer, who might be a teacher, parent, coach or youth group leader. There are several examples of year-round programming structures as well; one type is the “explainer”-style program in which students are trained to serve as docents and community educators at museums and other science institutions. We have also seen these offering structures and others incorporated into “ladder” programs in which it is possible for students to progress through several different types of offerings as they age. Students who stay involved with the same ladder program for multiple years might become a paid intern or employee of the providing institution, or have the option of participating in ongoing research with professional scientists.

Many OST program directors working with underserved populations report that flexible program entry and exit points are significant for including underrepresented groups in OST science experiences. For example, the director of a teen program for underrepresented minority youth at a science museum stated:

“Our teen program is a work experience internship program. They can start as young as 12 and they go until they’re 18. And we actually have over the years kind of had a rolling admissions thing... It’s not like if you don’t get into the program at 12 you can’t join later on.”

- *Student Audience*

Our database attempts to track both target and actual student audiences for each offering. Audience variables include demographic information about gender, ethnicity and socioeconomic status (when available). We also include age and grade level information, and any available information about students’ pre-existing level of engagement with science, required academic prerequisites and application materials. In terms of target audiences, we also track recruitment and retention measures. We are particularly interested in providers’ thinking around engaging underserved youth and populations who are traditionally underrepresented in STEM fields, including women, students of color, and students from low-income school districts. We expect audience indicators to be useful for learning more about student access to OST science experiences, particularly what groups are well- or poorly-served in what geographic locales, and what models emerge as common for encouraging students from underrepresented groups to pursue science education and careers. We also expect data about desired versus actual student audiences to help us develop a deeper understanding of overarching norms and goals, if any, among OST science educators related to access to science education for underserved groups.

Preliminary findings indicate that the financial cost or support associated with a program offering is a key variable in broadening or limiting participation in OST science for underserved students. For instance, the program director of a work experience targeting underrepresented minority teens discussed the importance of providing financial support for low-income students.

Although the program serves both low-income and affluent students, the financial stipend deepens underserved students' commitment and increases their access to OST science. In contrast, affluent teens who use the program to bolster their college applications express less commitment to the program.

“Everybody needs to do at least one four hour shift a month. And we have a number of kids who do just that, bare minimum. Who come to the meeting and work the shift, and that's all that they do. And we have some kids who work here every single week and try to pull it together as a real job. And I would say that generally it kinda tends to break down into those students who need it to be an actual job so that they don't have to take another job in addition to participating in the program. Cause it tends to break down in that way that our students for whom the pay is crucial tend to have a larger commitment to the program than those who it's one more thing on the list of experience building things that they're trying to do.”

- “*Real Science*”

Almost every program offering in our database describes itself as including “hands-on” activities. However, this term means many different things to different people. We aim to examine programs along a spectrum of content, focusing on the extent to which students are engaged with “real” science. Authenticity in this context can be determined from variables such as the degree of inquiry in science activities and design in engineering activities, whether and how activities are tied to real world-applications, links drawn between what students are doing and the broader science community, the level of scientific expertise among program staff, and how much mentorship (if any) students receive from working scientists. Collectively, these authenticity indicators are expected to relate strongly to whether the program sparks lasting interest and engagement in science among participants.

Preliminary interview findings indicate that programs that have been identified as exemplary by practitioners in the field exhibit many of these markers of “real” science. For example, a program manager described the combination of inquiry and authenticity in a long-term program offering for underserved teens at a science center. The authenticity and “real-world” nature of science content may be particularly important for students from underrepresented groups.

“The program has cohorts of ten to twelve kids who usually stay with it for three or four years, and those kids are doing actual scientific research. Usually it's water quality testing or other things like that... They actually discovered that there was some illegal dumping happening in a local stream and they've been working with the EPA to try to get the violator brought to justice... and it's definitely targeting kids from underrepresented neighborhoods and getting them engaged in scientific research in their neighborhood that's specifically relevant.”

Program offerings identified as exemplary often combine inquiry-based STEM pedagogy with positive youth development activities, such as community-building, mentoring, and career

development. The director of a well-established STEM after-school offering for girls described the program's typical activities.

“We start just about every session with an ice-breaker, and those vary from being fun and energizers, to helping the girls really get to know each other and in some cases it has a connection with the subject matter or with thinking about careers. And then we jump into the hands-on activity for the day. In some cases it's a one-day design challenge and some cases they're working at a longer project that might take three to six weeks to complete, and then try to find time at the end for a wrap-up and a reflection. We have role-models come and visit the girls, and talk a little bit about who they are and what they do, and their journey to where they got to their career. And we take the girls on field-trips, which are day-long trips to an organization where they get to see science or technology or engineering in action and spend a day meeting with role-models, touring the facility, and then having time to connect over lunch with role-models and talk more with them.”

- *Desired Outcomes*

Youth science offerings often seek to develop interest and foster talent among young people, instigating a life-long interest in science and encouraging them to pursue further science education and careers. At the same time, many OST science education providers place a high value on more immediate youth development goals such as increasing student confidence and self-esteem, fostering leadership abilities, improving science literacy, providing mentoring from supportive adults, connecting students with a community of other learners, and offering engaging learning and personal growth opportunities for youth who many not be well-served by the traditional school system. One of the most interesting findings from our data collection so far has been the apparent wide-spread tension in the OST science education field between prioritizing scientific workforce development outcomes versus focusing on other youth development outcomes -- especially as this relates to tensions between issues of funding and consciousness about cultural context. However, several directors of programs that have been identified as exemplary by other practitioners in the field see these outcomes as complementary. Workforce development outcomes will not occur without the foundation of positive youth development.

“It's important that we do all of this for science, but it's not just about science. But at the same time, I don't think we would get the same result in science, if we didn't have these other components, the personal and youth development components. I think we wouldn't be as exciting in the science component, and vice versa.”

Program offerings that have engaged in longitudinal evaluation—though rare—assert that positive youth development and the sense of belonging fostered by the program contribute to students' educational and career aspirations and choices.

“The students do cite that the social connections that they've made here were important in supporting their decision to, to stay with science if they chose to stay with science.”

Providing a safe place for students to explore, investigate, and discover in STEM fields contributes to students' gains in intellectual skills and their development of the personal temperament needed to become a scientist.

“They tell us, because one of the things we really try to emphasize is making mistakes is fine and it's all part of learning, and that perseverance is really important, so we do hear about them having increases in confidence and feeling that they can overcome a challenge and are better at problem solving.”

- *Cultural Relevance*

This indicator tracks offerings' level of theoretical and practical engagement with their students' cultural contexts, integration with local communities, and level of collaboration with parents and families. It also tracks whether and how each program engages students themselves with these big-picture concerns through discussions of issues of underrepresentation in science careers and the role of science and scientists in their lives and communities. We expect providers' level of consciousness about cultural relevance to be important in influencing their effectiveness at achieving goals such as reaching underserved populations, successfully contributing to a variety of immediate youth development outcomes, fostering a long-term interest in science, and broadening access to educational and career options in STEM fields. While preliminary interview analysis has demonstrated that many providers have a consciousness of diversity and an awareness of the importance of culturally relevant pedagogy, we will not know how widespread this consciousness is until the completion of the larger database.

Significance of the Study

Proponents argue that science-focused OST education can extend and deepen school learning, allow time for hands-on experiences that generate curiosity and inspire interest, and promote academic achievement (Bevan & Semper, 2006; Chi, Freeman & Lee; Dierking, 2007; Friedman & James, 2007; Little, Weimar & Weiss, 2008; Schwartz & Noam, 2007; Walker, Wahl & Rivas, 2005). Many programs are also motivated by long-term aims such as improvement of the scientific workforce, greater public science literacy, and engagement of youth from groups traditionally under-represented in science (e.g. Congressional Commission 2000; Friedman & James 2007; Coalition for Science After School, 2008). Despite the broad-based appeal of youth OST science programs, evidence linking their immediate outcomes to medium-term and adult outcomes is lacking; yet, questions about effectiveness cannot be fruitfully addressed until we understand where, how, and to whom these programs are (or are not) offered.

Out-of-school-time science education is an emerging field with a diversity of creative and innovative program models for middle- and high-school aged students. Throughout the field, there are some overarching tensions around goals and best practices, however practitioners also share a common intention of increasing student access to quality science education. There is a growing interest in communication and collaboration between program providers. Currently,

networks to share information and resources tend to be fairly localized by geography, student audience, or provider type, but broader efforts to develop a more inclusive network are beginning at both regional and national levels. By bringing together and describing these varied and widespread efforts, this mapping study will develop a cohesive picture of the OST science landscape, informing educators and policymakers and providing a foundation for future investigations of youth outcomes and the processes by which they occur.

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