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FORUM

Schools and informal science settings: collaborate, co-exist, or assimilate?

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Abstract In this metalogue we build on the arguments presented by Puvirajah, Verma and Webb to discuss the nature of authentic science learning experiences in context of collaborations between schools and out-of-school time settings. We discuss the role of stakeholders in creating collaborative science learning practices and affordances of out of school time and formal science learning contexts. We contend that authentic science learning experiences are those where science learning happens within a social milieu and advocate for true collaborations between schools and informal settings in ways that emphasize the goals of the collaboration and strengths of each setting.

Keywords Authentic science · Informal science · Out-of-school time · Formal and informal collaborations

Creating authentic science-learning experiences has been a long-time goal of science educators, in both formal and informal settings. Authentic science-learning events are those where students learn science in ways that parallel that of a practicing sscientific culture. In other words, they learn science through their participation in the collaborative practices of a science-focused culture, thus science-learning and social interactions become inextricably linked in an authentic science context. Anton Puvirajah, Geeta Verma and

This review essay is a critique of Puvirajah, A., Verma, G., & Webb, H. Examining the mediation of power in a collaborative community: Engaging in informal science as authentic practice. *Cultural Studies of Science Education*. doi:10.1007/s11422-012-9394-2.

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Horace Webb contend that an informal science setting, like a robotics competition, affords the linguistic interactions and social structure similar to that of practicing science culture, like a laboratory. Drawing from a Vygotskian/Deweyian framework, Puvirajah, Verma and Webb describe how the activities that students engage in provide them opportunities to learn and use scientific language necessary for participation, and assume the roles of engineers—people who design, test, critique, re-design and work towards a particular challenge or goal. They also elaborate on how such activities allow mentors and students to work collaboratively so that power issues can be reduced. This research triggers a number of important discussions that are relevant and necessary to advance our abilities to support students in science learning experiences. The article ends with an urge for schools to move towards incorporating authentic science learning experiences. We begin our forum response from this point and discuss the role of stakeholders in creating collaborative science learning practices and affordances of out of school time and formal science learning contexts. In this article we use the term out-of-school time (OST) to describe science learning that happens outside of the classroom in ways that are usually collaborative, voluntary, non-linear and semi-structured.

We use the genre of metalogue (Roth and Tobin 2004) to engage in our discussion because it allows us to use both our personal and professional perspectives to illuminate key points in the article. Metalogues are narratives written in a dialogic way to preserve polyvocality and polysemicity. Amy DeFelice is a high school teacher in a science-themed urban public high school. For over 7 years, she has taught in the life sciences and has worked on several key collaborations between her school, a local university, and informal science institutions to bridge classroom-based and "real-world" science learning experiences. Preeti Gupta is an upper-level administrator at a natural history museum and has had almost two decades of experience developing, managing and researching programs for youth learning in informal science settings. Jennifer D. Adams is a university-based researcher and educator with almost two decades of professional experiences in the formal classroom, museum and other informal science settings. All three of us bring our respective experiences to this discussion.

What roles do students, teachers and science mentors play in creating a collaborative science learning and practicing community?

Puvirajah, Verma and Webb cited several key factors that contributed to building of community amongst the student and teacher participants in the robotics competition including, shared goals and understanding of stakeholders' respective strengths and limitations in knowledge, and skills necessary to reach the shared goals. The use of language in the competition revealed these factors and contributed to a sense of community where stakeholders were able to co-construct knowledge through shared discussion and critique of each other's knowledge claims. Here we begin our discussion by first examining the meaning of a collaborative science learning, teaching and practicing community in OST, including programs where students are immersed in the practicing scientific community.

Amy In a truly collaborative community that is enacting science activities, all participants contribute in different capacities holding different roles, to reach the goals of the community, or collective. Language is a tool to mediate individual roles and to communicate ideas to the collective. The larger science community has its own norms for enacting science activities. New members to the science community must learn these norms in order to be accepted into the community and to communicate effectively with other community members. Less experienced community members learn norms from more experienced members by engaging in science activities together. Learning and applying the language that scientists use in practice is also necessary for emerging scientists. In order to be a truly collaborative science community the more experienced members must also listen to and be open to the ideas of the less experienced members. When emerging scientists participate in a science activity with other scientists they are learning more than just the science content, but also the language and behavioral norms of the science community. For me, this article resonated with what I hope are my students' experiences when we seek out collaborations that enable them to learn the collaborative practices of the scientific community through lab internships. Although this is different from the robotics competition—where students and their teacher engage in science learning in a informal setting—the lab setting is formal for the practicing scientists that are hosting the internships, but an informal or out-of-school science learning opportunity for my students but they are also able to learn the language of the community and enact a role where they feel that they are valuable contributors to the scientific knowledge generated there.

Jen Amy, you noted a significant parallel between the robotics competition and a practicing scientific community—that language is a means of building and learning shared practices in a given community. It is an opportunity for students, teachers and scientists (in the case of your students) to learn from one another in a way where levels of expertise are respected and each person has the opportunity to take on a more central leadership role as they develop the language and corresponding skills in the area of interest. Koshi Dhingra (2008) reviewed articles that examined science education spaces (both formal and informal) in terms of terms of identity development and participation in a globalized economy. One of the design features of effective science education contexts mentioned are opportunities for the exchange for the funds of knowledge between students, teachers and/or scientists, thus students, teachers and/or scientists learning and practicing together have the opportunity to exchange knowledge and build a collaborative practice. In this sense each stakeholder group serves some sort of mentorship role (whether implicit or explicit) as each are learning culture from the other.

Amy That sounds promising, however opportunities are limited in most schools for students to participate in informal and formal science activities with more experienced adults (including teachers and mentor scientists). At my school we have managed to seek out and collaborate with individuals and institutions to provide opportunities for our students to engage in science activities with more experienced scientists. Through the NSF-funded GK-12 City-as-Lab program, graduate science students, or Fellows, from Brooklyn College work with high school science teachers to create lessons and projects in the high school classrooms, with much of the activities focused on place-based science learning. This is a way of bringing practicing scientists into the high school classrooms. In addition, in my school, which is a specialized science high school that serves the local underrepresented community, we select students in the 9th grade, who show a strong interest and potential in science, to participate in a three-year science research program starting in the 10th grade. During the 3 years and based on students' interests we seek out and pair students with mentor scientists in the surrounding community. Students conduct authentic science research with their mentors in addition to learning how to navigate entry into a career in science. Students share their science research at local and regional science fairs and some 12th grade students have served as co-authors with their mentors on published papers. Although I have not formally documented the post-graduation outcomes, I know that these students have had more opportunities to learn the norms and language of the scientific community and therefore will have more social and cultural capital as they pursue science activities in the future. Most of the students who have participated in this program go on to pursue science majors in college.

Jen Although these opportunities are limited, these kinds of collaborations often prove fruitful for the students involved. I have been involved in several programs where students from underserved communities have had some kind of direct contact with practicing scientists—whether through lab internships, workshops or ongoing informal interactions. Like you, Amy while I was working with these programs, I was not able to document the outcomes, but I know anecdotally that these students are more likely to successfully pursue science majors and careers. Like many people today, I am able to keep in contact with some of these students and their peers through social networking media so I have, in essence, been able to follow their career trajectories from these OST programs through college and into various science careers, including veterinary science and microbiology, and higher education pursuits. All of these particular students come from one or more underrepresented categories—lower socioeconomic status, immigrant or first generation Americans, female, linguistic and/or racial minorities, and from public schools with meager science-related resources. Preeti and I recently received a grant to have dialogues with some of these students to learn about the role of their OST participation in their pursuit of science careers in spite of the odds against them. With that we plan to advance knowledge in the field about the key factors that influenced their persistence in science in ways that will inform program design, research and evaluation. The realities of the schools that they were in would not have afforded them the resources for their science-related successes; they would not have had these authentic experiences that allowed them to learn and enact the cultures of science in ways that were more personally meaningful.

Preeti I struggle with what we know about the values of authentic science learning experiences and the realities of school. Amy points out that there are limited opportunities for students to participate in science research opportunities. There are far more students than there are scientist mentors and it is unrealistic to think that each science teacher can support large classrooms of students to engage in authentic science research. In a truly collaborative community, what does it mean for schools and institutions devoted to OST learning to work together where each contributes to the overall agenda of developing youth to become engaged with science and be able to critically think and investigate ideas in science? Out-of-school time spaces afford students particular opportunities. School time experiences afford different opportunities. The Center for the Advancement of Informal Science Education published an Inquiry Report that outlines both the structural and social properties unique to formal and informal science (including OST) contexts (Bevan et al. 2010). The authors of this report encourage educators to look at collaborations between the two contexts in terms of affordances of each to realize a vision of science education learning that "can 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" (Bevan et al. 2010, p. 13). How can we leverage the features of both spaces to truly collaborate in ways that improve science education for all students, but especially those who are marginalized from science?

Jen This is an important but tough question because there are quite a number of issues at play when we think about science education in terms of collaboration. Elsewhere we discussed museum-school partnerships, namely the historical and cultural disconnect that often exists between partnering stakeholders (Gupta, Adams, Kiesel and Dewitt 2010). We talked about creating effective collaborations in terms of recognizing the perceptions that each stakeholder group has of the other(s), i.e. learning each other's institutional cultures, and the importance of all stakeholders having not only common goals, but also a shared language that would be used as a key tool in achieving those goals. This parallels with Verma et al.'s article in that the students and teacher not only had a shared language, but the use of the shared language helped to mediate power relationships within the group and achieve collective goals. While this mediation of power may be more difficult in the context of collaborating institutions (referring again to history and the most powerful driver—funding), the bringing of all stakeholders to the table to establish shared goals is important. Building a shared language and cultural practice among institutions takes much more time.

What affordances do school and OST contexts bring towards a true collaboration?

Preeti Schools are often disparaged for being rigid, providing very linear learning experiences and teaching to the tests, which manifests itself in drill and kill exercises and limited teaching—breadth, rather depth of content. As a place, school feels much different, often imprisoning and confining to students and sometimes, teachers (Freire 1970). At worst and with the constraints of assessments and standards, teachers are often unable to devise lessons where students have more autonomy, can bring in prior knowledge and experiences and have the flexibility with class time to make mistakes and messes during science activities, as would happen in an authentic science context.

Amy In the science classroom the teacher is positioned as an authority figure whose role is to direct student learning through facilitating different learning experiences. Generally teachers tell students what they "need to know" with little explanation as to why they should know something. Additionally, student voices and curiosities are often silenced or ignored in order for teachers to meet their planned science lessons and teach the required curriculum. Furthermore, school contexts often discourage and punish non-academic talk during class time, another barrier to students' bringing their cultures and prior knowledge to bear in the science classroom. Thus, students have very little power or agency over their own learning.

Preeti However, when done well and in terms of affordances, schools have the ability to build increasingly complex understandings of scientific phenomena and processes through sustained contact with the students and teaching and learning expertise (Bevan et al. 2010). A school structure allows for a scope and sequence of scientific ideas, and while some might see it as a barrier, mandatory attendance for students is actually a benefit in being able to guarantee that students will be able to build on concepts grade after grade. In theory, this idea is solid, but where schools often fail at is engaging students. Students express boredom and structured curriculum, like the scope and sequence, feels like a constraint, rather than a programmatic opportunity to develop conceptual understanding.

Jen I agree with you Preeti that we need to recognize school science for what it is, however research has shown that students, especially marginalized students, are often turned-off by school science because it is inauthentic and lacks a connection to their lived experiences (Roth and Tobin 2007). Similar to what Puvirajah, Verma and Webb point out, OST spaces afford students expanded opportunities for participation in science in ways that allow them to build an identity and cultural practices in science first using their own languages and references. It is well documented that out of school environments can successfully *engage* students (Gupta, Adams, and Dierking 2011). In an afterschool setting, students and teachers also have more opportunities to engage in science as a part of their social interactions rather than separate from it. For example, they could talk about their favorite recording artists while they are watching and waiting for earthworms to escape to the surface of the soil from a burning mustard solution. These are opportunities for youth to develop and enact their hybrid identities that position science as something in which they engage in various aspects of their lived experiences (Rahm 2008). Integrating multiple ways of knowing in science learning experiences is a way of foregrounding *both* the social context and the science activity (Rahm 2008). Allowing these kinds of interactions in schools could create school cultures where social talk and science talk are intermingled and resemble what real work environments are like. If we think about our work environments in almost any field, we do not leave behind social talk while we engage in talk specific to that field.

Preeti Another luxury of OST is that it affords us opportunities to let students who are have different degrees of knowledge and skills to navigate their way through the process. Even more, Amy, you pointed out that in school, students often are learning material, but do they know why? Schools and teachers often are not able to devote time to why studying a topic is important because of school structure of a number of topics to cover within a given time frame. This is the opportunity for schools and informal science programs to work together. Informal programs have the freedom for students to realize the why behind the investigations and the labs. For example, a well-known research and development organization, Education Development Center Inc, created an NSF-funded after-school science curriculum called Explore-It intended for middle school audiences in OST environments. One of the units, Wiring a House,[1] was implemented many times at the local science center. A major strength of this unit is that it has an obvious relevancy for the learner. We can assume that most students in schools live in homes that have lights, buzzers and switches that control them. While students might experience diverse living conditions everybody has witnessed that switches control lights, bells and other amenities. In this unit, students learn to wire their own cardboard house, and have the freedom and flexibility to wire each room of the house as they see fit. I have witnessed students engaged in this activity and observed how the "mistakes" they make quickly becomes learning opportunities due to the immediacy and relevancy of the activity. For example, they make the switch control the bathroom and the bedroom at the same time. Students realize the difference between series and parallel circuits quickly because they see the need and relevance of having these different approaches to circuitry while knowing through their lived experiences that these two rooms need separate controls. Could this unit be taught in school? It could, but such a project requires a lengthier period of time where a 45 min period would not suffice. There are many materials required with some being expensive, such as motors and batteries. Materials management can be difficult for a novice teacher even if the students are well-behaved and are in the habit of working in cooperative groups and many schools do not have the funding for lab materials.

Jen I think that we need to think more about the hybrid spaces—those spaces in between schools and OST spaces—that bridge the two contexts affording students more agency of their learning within structures that are content and process focused. I know that there is an ongoing discussion in the Informal Science Education community about making connections to school science, but I think the two contexts still largely exist in their own silos, both in research and in practice.

[1] http://npass2.edc.org/resources/curriculum-guides/wiring-house retrieved January 3, 12.

Amy As a teacher, I struggle with figuring out how to make this hybrid space a possibility. I had the first-hand opportunity to observe and participate with my students in an informal science-participation activity during a week-long vacation. While the students engaged in collecting and analyzing environmental science data in a local park, I was a participant-researcher learning about how students were experiencing the program. The science program was less structured than what I was used to doing in school-related science experiences. For example, during activities, students were told to record anything in their journals that they thought was important and students were not assigned specific tasks to complete during the activity. Without specific directions from adults, most students were actively involved and participating in different activities to different degrees. This was a much different learning setting than what I try to construct in the science classroom. At first I was uneasy with the lack of structure and individual accountability because I observed some students more engaged than others. However, in this setting I observed how students were in more control of their learning and therefore had more power in this alternative place away from the school setting and therefore could choose their level of engagement without consequences. This experience reminded me of how important it is to provide choices for student participation in the classroom setting. With choice, students have agency for their own learning. With the constraints of "getting through the curriculum" that come with classroom teaching it is challenging to step back and act as a facilitator of learning with less structured tasks for students. Additionally, students have different levels of motivation and the classroom teacher is responsible for all students in the class learning. Classroom teachers may be able to transfer OST methods of teaching and learning into classroom settings and sometimes include science research projects. However, I don't think that the role of practicing scientists completing authentic research with students can be replaced by the classroom science teacher. Collaborations to allow for practicing scientists to engage students in authentic research experiences in and out of school must be pursued to improve science teaching and learning.

Final thoughts

The article ends the discussion with an urge for schools to move towards incorporating authentic science learning experiences that are similar to that of an OST setting. We discussed that authentic science learning experiences are those where science learning happens within a social milieu and we advocated for true collaborations between schools and informal settings in ways that emphasize the strengths of each setting. We believe that it is unrealistic to urge schools to be more like informal science settings as the structure and resources that make schools what they are do not often lend themselves to ongoing authentic science activities. The important thing is that the collaborators have shared goals and a shared language for articulating those goals. It is also helpful if the collaborators have an awareness of each other's culture and perspectives as this influences individual goals for collaboration. The proverb, "it takes a village to raise a child" is suitable here—as it takes a village of institutions to raise future scientists. One kind of institution cannot and should not be solely responsible for educating the next generation of scientists, especially given the diversity of situations and institutions in which practicing scientists will actually find themselves and the diverse pool of scientists that we, as a nation, hope to produce.

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Dr. Preeti Gupta recently joined the team at the American Museum of Natural History to lead the youth initiatives at the institution. Previous to this position, she worked at the New York Hall of Science and was responsible for strategic planning and program development for the internationally replicated Science Career Ladder Program, as well as teacher professional development, out of school time programming, digital learning, family learning and the museum's science technology library. She has a Bachelor's Degree in Bioengineering from Columbia University, a Master's Degree in Education from The George Washington University and a doctoral degree in Urban Education from the City University of New York Graduate Center. In 2005, she won the Inaugural National Roy L Schafer Leading Edge Award for Experienced Leadership in the Field from the Association for Science Technology Centers. Her research interests include teacher preparation, youth employment and workforce development and the role of cultural institutions in mediating identity development in youth.

Amy DeFelice is a high school life science teacher at Brooklyn Academy of Science and the Environment, a New York City public high school. Ms. DeFelice holds a Bachelor of Science degree in Biology from Fairfield University, a Masters of Science degree in Adolescent Education from Canisius College, and is currently pursuing a Ph.D. in Urban Science Education at the City University of New York Graduate Center. Her research interests include outdoor science education, place-based science education, and students' motivation and interests in studying science.