

## IS THIS SCIENCE? A PILOT STUDENT-SCIENTIST PARTNERSHIP PROGRAM

In order to provide students opportunities to participate in authentic science experiences, four eighth-grade students were partnered with four astronomy graduate students to complete a 12-week research project. In its pilot phase, this student-scientist partnership program resulted in mixed experiences for the student participants. Out of the four partnerships, only two successfully completed the project, mostly due to practical issues. Both students who completed the project experienced significantly different science practices in their scope, authenticity, and depth. These experiences are explicated through the lens of participatory science, with successful practices defined as those that allow students to participate in a culture of science.

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### Introduction

There is a strong push in science education to involve students in authentic science experiences (American Association for the Advancement of Science, 1993; National Research Council, 1996; Roth, 1992). One method of creating authentic experiences is to expose students to the thoughts and actions of a scientist. Through working “at the elbow” of a scientist, students are meant to experience the role of scientist as an apprentice (Barab & Hay, 2001). This paper details the experiences of secondary students working with graduate student researchers and examines the relationship between the students’ experiences and their participation in a culture of science, thereby adding to the knowledge base of participatory partnerships. These partnerships were formed in order to give students an opportunity to participate in authentic research experiences and impact the graduate students in a meaningful way.

### *Student-Scientist Partnerships*

Taking cues from successes in another partnership program (Busch & Tanner, 2006) and building on the knowledge of apprentice and mentorship programs, I designed a small-scale program partnering four eighth grade students (the “students”) with four astronomy graduate students (the “scientists”) to complete an authentic research project in astronomy. In this partnership, the students were charged with doing the research, guided by the expertise of the scientists. Participating in scientific practices with scientists, while a precondition for apprenticeship learning, does not guarantee students’ entrance into a scientific community of practice, as they may leave such experiences without a changed view of the nature of science (Bell, Blair, Crawford, & Lederman, 2003). In recognizing this issue and the young age of the students, I define a successful partnership as one in which the students *participate in a culture of science*, not necessarily alter their views on the nature of science or increase their science knowledge (although these may be additional benefits).

I base my analysis on the assumption that interactions are generative, that is, interactions create culture. This assumption stems from the idea of culture as a system of participation, where “any action in the world, including verbal communication, has an inherently social, collective, and participatory quality” (pg. 46, Duranti, 1997). One way to conceptualize this ideal of culture is through participation in a community of practice (Lave & Wenger, 1991), where learning entails a trajectory from the outside (periphery) to the inside (core) of the community. To use this as a framework to evaluate their participation in a culture of science, I adopt the six learning characteristics of participatory learning environments from Barab and Hay (2001). These six characteristics provide a descriptive framework for determining the extent to which the students participated in a culture of science, specifically the degree to which they are engaging in participatory practices. They are (with my shorthand notation in brackets):

1. *Learners do domain-related practices to address domain-related dilemmas* [*Astronomy Practices*]. As part of the program design, students chose their research topic under the guidance of the scientists. The students had little or no formal background in astronomy, and therefore the topics they were introduced to were closely allied to the work of the scientists. In their work with the scientists during the program, the students took part in three main types of practice – data collection, data analysis, and questioning.
2. *Scientific and technological knowledge/practice are situationally constructed and socially negotiated* [*Social Construction of Knowledge*]. This trait of participatory learning is best characterized by the use of scientific discourse and interactions that create individual meaning (Barab & Hay, 2001). In studying such interactions, I looked for language indicative of a culture of science and identified distinct interaction schemes for each of the partnerships.
3. *Learning is participatory, occurring “at the elbows” of more knowledgeable others, including teachers, scientists, and peers* [*Participatory Learning*]. The one-on-one relationship between students and scientists allowed for many opportunities to learn science while practicing science, and the students experienced this to varying degrees.
4. *Practices and outcomes are authentic to and owned by the learner and the community of practice, and are in response to real-world needs* [*Authentic Practices*]. Even though the two students spent many hours working on tasks associated with their projects, these tasks and their outcomes were not always authentic in astronomy or in the student’s mind.
5. *Participants become a part of (developing an identity as a member of) a community of practice* [*Membership in a Community of Practice*]. This character of participatory learning implies a movement from novice to expert, and an associated adoption of science practices. A full and central membership in astronomy was not the goal of the program and was not expected to occur for such young students in such a short span of time. However, this project did attempt to introduce the students to an astronomy community of practice and let them know of its existence, through legitimate forms of participation. There is some evidence of such

legitimate participation and glimpses of incremental movements towards a more central role in astronomy.

6. *Formal opportunity and support for both reflection-in-action and reflection-on-action [Reflection]*. Unfortunately, this important aspect of participatory learning was not used during the pilot of this project and this may have detracted greatly from the overall impact of the program on the students. The only types of reflection done by students (or scientists) were in their email correspondences to each other, which were not designed to provide a reflective outlet. The partnerships were given access to an online discussion forum, but this tool was not used due to the students' limited access to sufficient technology.

### *Setting*

This partnership took place in a large city in the Northeast with scientists from a top-tier research University and students from a local public middle school. Each of the four students was matched to a scientist in February and they worked for about twelve weeks towards the goal of a presentation by the student in their science class at the end of the school year. Students were selected through an application process to verify their commitment, as the project required substantial out-of-school work.

The four participating students (3 female and 1 male) are Black and were in the same class at a public school where over 97% of the students are Black or Hispanic, with about 57% eligible for free or reduced lunch. The school has about 300 students in grades 6-10 and is within walking distance of the University. The scientists, two males and two females, represent a variety of backgrounds and are from numerous places around the country.

### *Evaluation*

In its first period of operation, this program experienced mixed results. Out of the four student-scientist pairs, two met with significant challenges and were unable to complete the project. Practical issues surrounding meetings and parental permission limited these two pairs to only a few meetings between them and there were too few interactions to assess the success of their common experiences. As such, I limit the formal evaluation to the two pairs who completed the project, with the caveat that these represent only half the program's participants but the significant majority of the experiences.

### *Methods*

To assess the various impacts of the program on the students, I took an ethnographic approach, combining direct observations, audio recordings, and document collection. Using these three methods to triangulate results, I aim to offer a more meaningful explanation of the program's social milieu than is possible with any single method (Mathison, 1988).

## *Partnership A: Yoshi<sup>1</sup> and Shaquila*

### *Partnership Description*

Yoshi (scientist) and Shaquila (student) progressed quickly through many topics at the outset of the program and began to narrow their focus to a specific topic early on. Yoshi commented that Shaquila “seems motivated and ambitious, but I don't think she was clear on how much effort was expected of her” (email correspondence, April 20<sup>th</sup>). They met together almost exclusively in a library at the University and communicated often over email.

### *Astronomy Practices*

In this partnership, their work centered on stellar astrophysics – the study of how stars are born, live, and die. In his daily practices as a theoretical astronomer, Yoshi's work involved mostly computer simulations and mathematical calculations, and Shaquila's science practices reflected this, involving mostly data collection and questioning. In their primary mode of research, Yoshi would pose a question based on an interest of Shaquila or a question she asked, after which she would look for information about that topic. She would collect “data” by looking for information on the internet, in encyclopedias, and in articles given to her by Yoshi. While this research technique makes sense in light of her limited background and Yoshi's expertise, the articles she was tasked with reading gave her some difficulties because she understood neither the terminology nor the concepts. In one of her emails to Yoshi, she proposed a solution to her data collection problem (finding information about a topic), thereby guiding her learning trajectory and taking responsibility for her own learning. She also asked numerous questions during their meeting times to clarify tasks, gain knowledge, or pursue a topic. Yoshi relates that “right after a lesson on gravity and the formation process of black holes, she asked if everything ends up becoming a black hole, or part of a black hole” (Yoshi, email correspondence, April 20<sup>th</sup>). This specific question came up again at a later meeting, when Shaquila clarified that her question was not about whether everything turned into a black hole but whether everything got sucked into a black hole.

### *Social Construction of Knowledge*

Shaquila's primary interaction mode with Yoshi can be classified as “repair,” which conversation analysts use to signify an attempt by one person to resolve a perceived problem within the conversation while maintaining its flow (Duranti, 1997). In one particular interaction, the process of repair practiced by Shaquila is indicative of her use of prior knowledge and of a negotiation of deeper meaning through questioning. This practice is aligned with practices of science, as scientists often engage in clarifications and negotiations to construct meaning from an interaction.

### *Participatory Learning*

The difficulty of a student research project based on practices in theoretical astronomy made Shaquila's learning process less participatory than that in the other partnership. Yoshi tended to default to a transmission model of teaching to communicate important

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<sup>1</sup> All names are pseudonyms

ideas and Shaquila recognized this, inserting her own questions and ideas into the conversation whenever possible, essentially taking her learning into her own hands. Thus, she lost out on the learning-in-action essence present in the other partnership.

### *Authentic Practices*

Most of the practices in which Shaquila engaged were motivated by the project and their outcomes were products in which she took pride. However, these practices were authentic neither in the field of astronomy nor in her own mind, as she held that the most important part of the project was the final poster.

### *Membership in a Community of Practice*

Over the course of the project, Shaquila became increasingly comfortable in the space, asking to only meet at the University instead of sometimes meeting at her school. She did not, however, take on practices specific to the project which would mark her movement towards expertise.

## *Partnership B: Anant and Makayla*

### *Partnership Description*

Anant (scientist) and Makayla (student) met on a regular basis, often for significantly longer than Yoshi and Shaquila (sometimes as long as four hours). Their first few meetings revolved around astronomical images, sparking discussions on numerous topics based on Makayla's observations. During these discussions Anant also tried to "break down the idea that all we're doing is a poster and the information is out there" (email correspondence, April 17<sup>th</sup>). They met exclusively at the University, as Makayla seemed to enjoy the change of setting from school.

### *Astronomy Practices*

Their partnership work centered on collecting and analyzing data, with Makayla asking questions throughout the analysis. Specifically, Anant began by teaching Makayla about galaxies before moving on to an investigation about differences between red and blue galaxies. To pursue this topic, Anant suggested some online databases of astronomical data and Makayla chose ten galaxies of each type to compare. She did much of the data collection on her own, guided by Anant's emails, which freed up their meeting time to concentrate on looking at the data and working through the analysis together.

These sessions often found Anant thinking aloud and Makayla asking questions along the way. Makayla was highly involved in the process, contributing her knowledge and resources to the analysis. For example, during one of their final sessions together, Makayla came up with a highly descriptive and entirely original method for quantitatively describing galaxy spectra. In developing this method, she used one of her science class reference tables and pieces of information she learned from the database websites. She also was able to point out features of the galaxy spectra using proper terminology (e.g., emission and absorption lines) and identified numerous atomic features (e.g., Hydrogen, Sodium, and Potassium) without prompting from Anant.

### *Social Construction of Knowledge*

Makayla's interactions with Anant were primarily characterized by questions and displays of knowledge. During their meetings, Makayla asked many questions of Anant, from simple explanatory ones to deeper ones regarding complex issues, and Anant reciprocated by asking Makayla to clarify her thinking or provide an opinion. For example, in one exchange while looking at the distinguishing features of galaxy spectra, Makayla asked Anant "what is this?" and pointed out a particular feature. Anant told her the answer, but also pushed her thinking by asking if she thought the two features were different. Makayla nodded her head yes and Anant pushed further: "why do you say that?" Makayla often intertwined these question practices with displays of knowledge, which were rewarded by Anant regardless of their accuracy. In one instance, she identified the equation for redshift as "like a standard deviation," to which Anant replied, "yeah, exactly like the standard deviation" before going on to explain the concept in more detail.

### *Participatory Learning*

The nature of their interactions allowed Makayla to experience, hear, and see science practices done by/with Anant. There are many examples of Anant making her thinking visible for Makayla, who benefited greatly from this technique. This practice allowed Makayla to more rapidly adopt practices and eased the learning of complex ideas.

### *Authentic Practices*

Evidence suggests that Makayla found meaning in many of her practices and found them to be real, both in their outgrowth from early practices and in being motivated by project-specific issues. For example, in order to describe the shape of galaxy spectra, Anant explained why a qualitative description did not provide the necessary criteria to distinguish one spectrum from another. In resolving this issue, Makayla suggested a measure based on a number of specific parameters in her sample. This measure was something entirely new and specific to the needs of the project, providing a strong sense of ownership for her. This prompted Anant to name the measure after Makayla, an honor quickly taken up and embraced by her.

### *Membership in a Community of Practice*

As with Shaquila, Makayla also became very comfortable in the physical and cultural space of the Astronomy Department. By the end of the project, she became so comfortable with her role that she would arrive unannounced in the Department just to hang out. She also began to adopt practices derived from experiences with Anant, as when she decided to begin using a lab notebook to mimic the one Anant used.

### *Conclusions*

In its pilot attempt, a student-scientist partnership program produced mixed results for students. Using six characteristics of participatory learning, I evaluated the success of the program in allowing students to participate in a culture of science. This analysis found many instances of students learning in action and learning by transmission. Overall, this program seemed to provide a small number of experiences that allowed students to participate in authentic science practices under the guidance of knowledgeable scientists

but did not provide some critical aspects of apprenticeship experiences, such as opportunities for reflection. In some wonderful moments during the program, students were found to enact a culture of science and assume legitimate participation in the resulting community of practice, but these moments were not as frequent as one might wish.

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