

Impacting University Physics Students Through Participation In Informal Science

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Abstract. Informal education programs organized by university physics departments are a popular means of reaching out to communities and satisfying grant requirements. The outcomes of these programs are often described in terms of broader impacts on the community. Comparatively little attention, however, has been paid to the influence of such programs on those students facilitating the informal science programs. Through Partnerships for Informal Science Education in the Community (PISEC) at the University of Colorado Boulder, undergraduate and graduate physics students coach elementary and middle school children during an inquiry-based science afterschool program. As part of their participation in PISEC, university students complete preparation in pedagogy, communication and diversity, engage with children on a weekly basis and provide regular feedback about the program. We present findings that indicate these experiences improve the ability of university students to communicate in everyday language and positively influence their perspectives on teaching and learning.

Keywords: Physics education research, informal science education, communication

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INTRODUCTION

Informal science programs are prevalent among physics departments in the United States. The types of programs range from one-time events to intensive summer camps, and they can span the age range from grades K-12 to adult. The motivation for physicists to facilitate these programs include serving the local community, fulfilling grant requirements, and providing university students with opportunities to gain teaching experience. Broader goals of informal science programs also involve increasing the number of students from underrepresented groups majoring in STEM fields and improving the scientific literacy of the general population.

The value of informal science programs has most often been assessed based on the impact the programs have on community members. Studies have shown that children benefit from exposure to informal science by improved attitudes toward science and better understanding of science concepts [1, 2]. The commonly used term for informal science programs offered by academic and industry institutions is “outreach”; this expression carries with it the perspective that the experts (professional scientists) provide a service to the members of the community who lack expertise (children, parents, teachers, and science enthusiasts). This perspective on the role of educational programs (as a one way street) can be detrimental to the success of informal science programming. For instance, it relegates these activities to reside outside the core functioning and identity of

the university (which focuses on research and teaching). As such, the programs exist on the margins, which may contribute to minimal resources, lack of sustained commitment and limited expectations of participation. Cole et al. argues that the best chance for an informal science program to maintain longevity beyond the timespan of seed (grant) funding or the commitment of an individual faculty member is to treat the university and community institutions as equal stakeholders in the program [3]. When universities and communities follow this model of partnership all participants benefit, and do so in terms of their core functioning identities [4].

At the University of Colorado Boulder, the Department of Physics and the JILA NSF Physics Frontier Center have adopted such a model and established Partnerships for Informal Science Education in the Community (PISEC). PISEC develops and runs K-12 informal science programs with community partners in the surrounding county [5]. Through PISEC, we seek to study the impacts of our programs not just on children and teachers, but also on the university participants who facilitate the science programming. Recent work has shown that teaching has a significant influence on graduate student reasoning and research skills [6]. Studies on service learning have also shown a positive impact on university students [7]. In this paper, we present findings demonstrating the effect of participation in PISEC on university students’ communication skills and perspectives on teaching and learning.

DESCRIPTION

The PISEC program is based on the successful 5th Dimension afterschool programming model [3]. In PISEC, university student volunteers work with K-12 children from underrepresented groups on activities designed to improve their scientific literacy. The program takes place in a classroom or community center after school hours. The sessions usually run once per week for 60-90 minutes and occur for 8-10 weeks during a semester. In a typical semester, 4-5 university students attend a site with a teacher and 10-18 children on a weekly basis. Either the PISEC Director or an experienced Site Leader also goes to the site: she is responsible for helping activities run smoothly, dealing with small behavioral issues among the children, bringing notebooks and supplies, and providing transportation to and from the site. While supporting science activities, one university participant works with a group of 1-3 children during a session.

To prepare for their interactions with children, university volunteers complete a minimum of five hours of training prior to going to the site. This training includes an information session on the structure and format of the program and time for conducting the hands-on science activities that are brought to site. Participants are encouraged to provide feedback on all aspects of the activities. University volunteers also attend a workshop on pedagogy and diversity. During the workshop, university participants are presented with scenarios that may arise during the course of working with children and are asked to consider possible responses. For example, they discuss what approaches to take when a student does not draw the physically correct conclusion from an experiment. Another component of the training is centered on communication skills. Prior to the pedagogical workshop, students are video-recorded completing the Communication in Everyday Language Assessment (CELA) – this assessment consists of a student explaining a paragraph on speed and velocity from an introductory textbook as if “they are at the afterschool site talking to children who participate in the PISEC program” [8]. The PISEC Director, who is also the first author, then watches the video one-on-one with the student and discusses best practices of communication for a general audience. The university students repeat this exercise as a post-test at the end of the semester. Additionally, university students create a stop-action-motion [9] movie about their research that they show to the children during the program at the community site. They receive feedback while making these movies as to the appropriateness of their analogies, language and representations.

University participants in PISEC include undergraduate physics majors, undergraduates from other science majors such as biochemistry, graduate students from the physics department, physics graduate students who are also part of the JILA NSF Physics Frontier Center for Atomic, Molecular and Optical Physics, and post-doctoral researchers from both physics and JILA.

In this study, we examine the impact of participation in informal science by considering three representative PISEC volunteers. These students are indicative of the range of university participants in PISEC; they also answered surveys and recorded field notes on a regular basis. Student A is a second year physics graduate student studying ultracold molecules in JILA. His experience facilitating informal science prior to PISEC was limited to a few one-time events with K-12 students that he participated in as an undergraduate. Student B is a sophomore undergraduate physics major. She also was limited in her informal science facilitation but did have substantial baby-sitting experience. Student C is a first year physics graduate student performing research on x-ray lasers in JILA. He did not participate in informal science programs before PISEC, but he did express an affinity for teaching. Students A and B each volunteered at a middle school during the Spring 2012 semester and worked with 6-8th graders; Student C volunteered at one middle school site in the Fall 2011 semester and then at two sites (twice a week) during Spring 2012.

All university participants were asked to complete an initial survey (labeled “Pre”) about prior informal experiences and program expectations. They were also asked to write field-notes (labeled “Week n”) [10] for each of the PISEC afterschool sessions that they attended. At the beginning and end of term, they conducted the CELA video activity described above. At the end of the semester they also completed a summative survey (labeled “Post”) reflecting on their experiences. We draw from these self-reported descriptions, CELA videos, and observations of their practices to document the evolution of the university students’ perspectives during the program. Quotations from individual participants are representative of their responses throughout the semester.

TEACHING DEVELOPMENT

Over the course of the training and semester-long program, the university students demonstrated substantial progress in the sophistication of their pedagogical skills and perspectives on teaching and learning as evidenced from their field notes and surveys. For example, consider Student A, who writes:

Student A: [Week 1] “I found it hard to resist the urge to simply give the students the answers.”

Student A: [Week 5] “It was a little frustrating when there was a good move [in a laser chess game] to make that the students didn’t see. I tried not to tell them exactly which move to make, but instead I would say something like, “Where is the beam going, and where would you like it to go?” This seemed to work fairly well.”

Student A: [Post] “I tried not to answer questions directly, but instead reply with another question.”

While Student A exhibits an awareness of not teaching by telling, he demonstrates a shift in his perspective about how to achieve this end. During the first week and early in the activities, he struggles with how to avoid teaching by telling. By the end of term, he has developed a propensity (and practice as observed by the Site Leader) to ask students questions as a tool for Socratic engagement.

Similarly, we observe Student B making shifts in her reflections on teaching, noting a new awareness of teaching as a sophisticated profession that honors the expertise of teacher and student alike:

Student B: [Week 1] “Sometimes I found it difficult to come up with words I needed that weren’t big words, but the kids were a lot smarter than I expected and so it wasn’t really that big of an issue. They picked up on what I was trying to say and put it into words they understood.”

Student B: [Post] “I have a lot more respect for my earlier teachers. It’s a very rewarding experience when you teach someone something and they get it, but it’s also frustrating when they don’t. It takes a lot of patience to approach it from a way that doesn’t make sense to you, but makes sense to them.”

Finally, Student C demonstrates an increased awareness of the opportunities and mechanisms for developing children’s identity and engagement in science:

Student C: [Pre] “I want to show people science isn’t just for some elitist group of smart people but is for anyone who wants to work hard.”

Student C: [Week 7] “ “Jorge” and “John” did a lot of little experiments on [a fiber optic lamp]...Some of the experiments were pretty good ideas. I really like how they shined a bunch of different light sources through

the fibers and started shouting, “I made science,” and “Now I’m a scientist.” ”

Student C: [Post] “The most impactful day was when “Sara” was using the lens rail. Sara wasn’t so impressed at first, but when she saw how she could make the [image of the] light bulb upside down and bigger or smaller, she really got into it. She had a piece of paper out and was doing calculations about how big/small the image got when moving the lenses apart and for when there were three lenses...I didn’t really do anything either. I would occasionally give a hint, but she did all that on her own. It was really cool to see her explain it...”

While this last reflection, “I didn’t really do anything either,” is unclear, we suspect it is a developmental move by Student C, who begins to recognize that teaching is a subtle and sophisticated practice. Knowing when not to interfere, and how to provide only modest cues can be instrumental in the development of the children with whom we work.

COMMUNICATION SKILLS

Prominent members of the scientific community have recently called for the inclusion of public communication skills as part of professional scientific training [11, 12]. Physics students themselves recognize the importance and the difficulty of communicating science to a general audience:

Student A: [Pre] “One thing that I find particularly hard is to explain complex scientific phenomena to the general public, particularly young people.”

Student A: [Week 1] “I found it useful to work with another [university student] for my first session, because whenever I couldn’t think of the right thing to say, she usually would, and vice versa.”

Student A: [Post] “I learned how to better explain science to kids. I learned how to use analogies to relate difficult scientific concepts to ordinary, everyday things. I think it is very useful as a scientist to be able to explain what you’re doing to the general public.”

It is clear that Student A is initially aware of the challenges of communicating about complex scientific ideas with children. Through the PISEC training and afterschool sessions with children, Student A develops tools for communication (working with others, using analogies). Not only does this university student develop a sense of how to communicate but demonstrates this capacity through the pre and post

CELA results (explanation of textbook paragraph about speed and velocity as if speaking to middle school students):

Student A: [excerpt from video transcript: Pre CELA – continues to hold paper with prompt, fidgets with shirt, monotone voice] “Velocity generally refers to the rate at which something is moving and the direction it is moving. For example, velocity is something like - this car is moving 30 mph per hour south, where the speed is just 30 mph. The difference between speed and velocity can be more generically stated as the difference between scalar and vector quantities.”

Student A: [Post CELA – more vocal inflection, smiling] “Every day you move around a lot, you ride your bike or walk all the time. A lot of time you worry about how fast you are going. For example you have to get up in the morning and go to school and lets say you are running late, so you want to go really fast. But speed isn’t everything, you also worry about what direction it is because you have take a certain route to go to school. So velocity refers to not only how fast you are going but which way you are going.”

Student A becomes adept at using non-jargoned language and thinking of appropriate examples. He also displays more comfort with his imagined audience. Student B exhibits improvement as well – although she uses a similar analogy in both explanations, her post-video is peppered with questions asked of the imagined student audience:

Student B: [Post CELA] “When you talk about speed you only have half the information - Is this making sense? Let’s say you have a train and it’s going 50 mph - okay, that’s kind of fast, right? Is the train going past you? Away from you? This is kind of important, yeah? Are you guys with me?”

CONTENT KNOWLEDGE

While not a key focus of the program, we observe that these environments have the opportunity to foster university students’ content mastery [13]. Notably, we observe that these environments can develop both mastery of traditional content (for example review of known materials, as Student B reflects below), and mastery of pedagogical content knowledge and the nature of what constitutes knowing physics:

Student A: [Post] “I also learned some things from doing the experiments. I knew how they all worked in principle before starting them, but a few of the experiments were actually a little tricky to get to work

well. My experience in PISEC reinforced my belief that hands-on demonstrations and experiments are crucial to really understand science.”

Student B: [Post] “It allowed me to review the basics and gave me opportunities to play with things I never did as a kid. [The activities are] science, but of a different sort than what I’m used to. It’s looking at how people learn and how to let them learn better.”

DISCUSSION

Evidence of the positive impact of informal science programs on children has been documented [1]; we argue, however, that there is an *equal* opportunity for impacting university students in these partnerships. As such, we encourage the shift of an informal science education model at universities from one of “outreach” to one of “partnership.” While we are just at the beginning of these studies, we demonstrate that participation in informal science does positively affect university students, and we will continue to explore the parameters that impact these positive outcomes.

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