Acting in Our Own Self-Interests: Blending University and Community in Informal Science Education

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Abstract. Research in physics education has demonstrated new tools and models for improving the understanding and engagement of traditional college students [1]. Building on this base, the research community has bridged the gap from college to pre-college education, even elementary school [2]. However, little work has been done to engage students in out-of-school settings, particularly for those students from populations under-represented in the sciences. We present a theoretically-grounded model of university-community partnership [3] that engages university students and children in a collective enterprise that has the potential to improve the participation and education of all. We document the impact of these programs on: university participants who learn about education, the community and even some science; children in the community who learn about science, the nature of science and develop their identities and attitudes towards science; and, shifts in institutional practice which may allow these programs to be sustained, or not.

Keywords: Physics Education Research, Informal Science Education, Educational Technologies
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INTRODUCTION

While a great deal is known about educating students in physics, and increasing attention is being placed on the education of students from under-represented populations in physics [4], relatively little research has been conducted on student learning physics in informal educational environments, particularly for teaching in after-school settings to children from these under-represented populations [5]. In assessments of science content understanding in school settings, the achievement gap between majority and Black and Hispanic students persists [6], and the likelihood that these students of color take physics classes (in either high school or college) dramatically lags that of majority students [7]. In schools, particularly K-8, as a result of the No Child Left Behind legislation, the amount of time spent on school science is being cut in favor of focusing the "basics" of mathematics and English [8]. At the same time, physics majors are not being adequately recruited, prepared, or supported to teach physics in high school settings, especially in areas that serve traditionally under-represented populations [9]. This paper examines the potential for after-school, informal science education environments to simultaneously address the lack of support for students from under-represented populations to engage in physics, and to recruit and prepare physics majors to teach.

While federal funding has increased (to over $1B / year) to support after-school programs (such as Boys and Girls Clubs, and youth centers), these programs have focused on youth development, and not emphasized science [8]. Meanwhile, the traditional site of informal science education (that is not based on the internet or television), has been science museums. These museums serve an important role in science education; however, they tend to have only limited exposure to children [8]: they more likely serve students from majority populations, students visit only occasionally (one-shot interventions), and the time to engage children around exhibits is limited (less than one minute).

Our approach brings the social structures and resources of community-based programs (for reaching youth) together with the institutional resources and mandates of the university (for educating undergraduates and serving the state population). Unlike "outreach", or many "service-learning" models, our approach is to create environments that directly serve the interests of all participants, and the institutions involved. This University-Community partnership model builds on an extensive history of research [3,10] and is grounded in a variety of theoretical traditions, both in the intellectual development of children [3,10-15] and in the creation of environments that support such development [3,16-20]. In short, these environments authentically engage children in construction of scientific ideas through play, dialog, community debate, community-based projects and often the construction of physical artifacts for public display.

PARTNERSHIP MODEL

This model of university-community partnership is designed to serve the self-interests of participating institutions and individuals. University students (undergraduate, graduate and postdoctoral) are mentored (either through weekly preparatory meetings or a class on *Teaching and Learning Physics* [20]) to teach youth in these community settings. As such, physics majors / graduates with an interest in education and teaching have the opportunity both to learn the theories and approaches for effective education, and to use these theories into practice. These weekly programs allow university students to engage in education in a relatively low-commitment manner (3+ hrs / week) [21]. As students' interests and abilities develop, they can become increasingly involved, and ultimately take leadership roles in running these programs [22].

Meanwhile, these informal science programs run in the community, reaching children where they live and spend time out of school. The children help create the program by selecting projects of relevance to their lives. (Often the overall subject is set by the university students / supervisors; however, the children select projects and presentations within these topic areas.) Children use new educational technologies that help them develop an understanding of ideas in science and the physical world through play with simulations of complex physical phenomena [23], and express their understanding and ideas in creative ways, such as movie making [24]. While the university students are mentored and supervised by university staff with expertise in education and science, the children (and university students) are supervised at the community sites by community leaders who have expertise in youth development, supervision, and management.

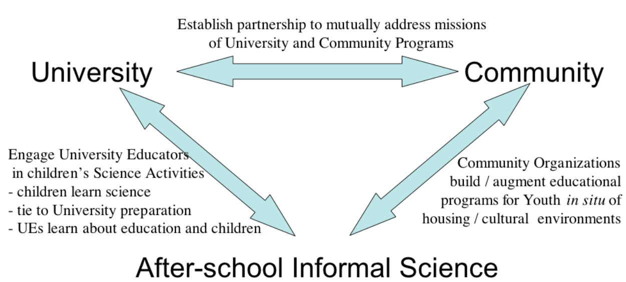

Figure 1: Model of University-Community partnership in the creation of After-school Informal Science programs.

DISTANCE LEARNING VERSION

Because the University of Colorado program in informal science education [21,22] is based on a long-standing model of involving university students in children's after-school community programs (but not in science) [3,10], we have investigated how students from the University of Colorado (CU) might augment parallel after-school programs elsewhere by infusing science content. In this sense, we might consider that the pedagogical content knowledge [25] necessary for teaching children might be distributed and delocalized. In pilot studies, described below, CU students participated via remote video with University of California students and children to offer science programming in the San Diego after-school activities.

SAMPLE OUTCOMES

Several versions of University-Community partnership program in informal science have run in the last few years. These range from after-school science clubs [26], and community-based science projects [21], to summer camps [22]. In each instance, these efforts are designed to have positive impact on the children, the university students and the institutions (university and community organizations). Here, we provide examples of the sorts of impacts these programs have on children and undergraduates.

Impact on Children

These partnerships have improved children's understanding of physics, beliefs about the nature of science and learning science, and promoted positive student interest in science. A companion piece [27] provides a case study of how, over three sessions after school, a third-grade student in a low-income housing center in inner-city San Diego develops an understanding of 1-D velocity and acceleration. Similarly, in a summer camp, using this same university-community model, CU undergraduates partner with the I Have a Dream Foundation to create a program where we observe positive impact for children studying states of matter in 4 ½-day sessions. Coded results from a pre-post survey of the particulate nature of matter [22] are shown in Fig 2. We observe that during this relatively short intervention, students develop more sophisticated understanding of matter.

In this same summer camp, students were issued surveys about their beliefs about the nature of science, their beliefs about learning science, and their interest in science. Results of the pre-post survey are shown in Fig 3. Generally, students show positive shifts, to more favorable, or expert-like, beliefs and attitudes.

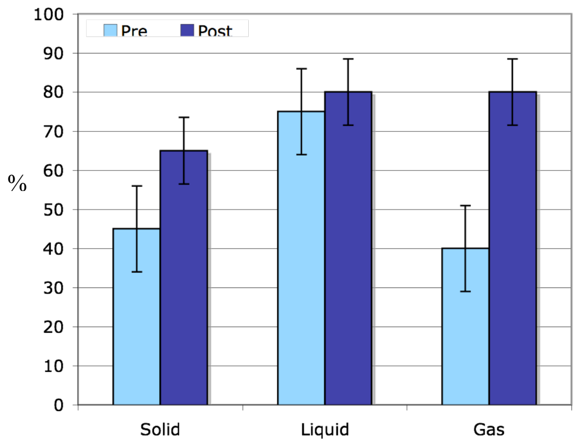

Figure 2: Pre- / post- evaluation of children's understanding of particulate nature of matter. Error bars std. error on mean.

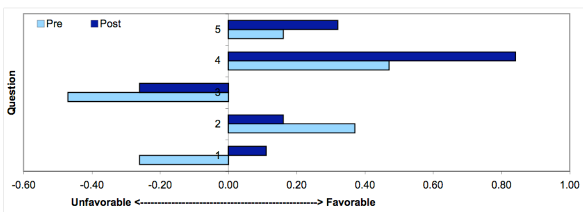

Figure 3: Student Attitudes & Beliefs (pre/post), answers on scale of -2 (unfavorable) to +2 (favorable) to the following:

1. I do not experience science in my everyday life. **
2. Science has little to do with the real world.
3. I would like to be a scientist when I grow up.
4. If I get stuck on a science problem my first try, I usually try to figure out a different way that works. **
5. I am not happy until I know why something works the way it does.

** Statistically sig shifts p<0.05 via two-tailed t-test [20]

Impact on University Students

Involvement in these University-Community partnerships is designed to positively impact university students': understanding of basic physics content, interest in science, understanding of and interest in education, and appreciation for working in diverse environments. Previous work [20] has documented the impact of these programs on undergraduate's mastery of the content. For example, the university students learned content from participating in the *Teaching and Learning Physics* course where they spent a semester both studying student learning in E/M and teaching these concepts to children in the community. Their average normalized learning gains on the Conceptual Survey of E/M were 51% (±8%, pretest 54%, post 74%). These undergraduates already had one to three courses in E/M.

At the same time these university students can develop an understanding of teaching and education, as well as increased interest in the fields. In case studies of individuals participating in the Teaching and Learning Physics course (coupled to community programs), students universally develop a more in-depth understanding of effective pedagogical practices [20]. For instance from "statements of teaching", one student writes at the beginning of the program:

> *There seems to be two ways of going about [getting people to learn]. One school of thought is that repetition is how one learns, and the teacher should focus on the most important ideas and go over them repeatedly. The other methods is to saturate the students with information... I have no opinion on which method works better...*

And after a semester of teaching in the community:

> *I believe that teaching is less telling and more leading through interactive experiences. It is important for a teacher to know the subject material and be able to convey it clearly, but it is equally important for a teacher to be able to prompt students into learning experiences through which students learn on their own, and in the process own the knowledge themselves...*

Similarly, these programs can have a dramatic positive impact on students' interest in education and teaching. In post-camp reflections, the two undergraduates who ran the 2006 summer camp on states of matter reflect:

> STUDENT A: *Coming into this camp, I did not really know what to expect, ... It was my first time ever teaching, ..., and for four days I had about as much fun as I ever had doing anything. This was definitely one of the best experiences of my life. .... But perhaps the most amazing thing about the whole experience was how much the students learned. I knew I was teaching, but it was hard to gauge how effectively I was doing so. .... I learned so much about how much work goes into developing lessons; ....*

> STUDENT B: *Being given the opportunity to have an influential role in the curriculum development and to be a lead instructor for the summer camp was the most valuable experience I have had as a future secondary science teacher. ... This empowering leeway allowed me to truly grow as an educator, develop my teaching philosophy, and learn to adapt to the classroom environment. I was also an integral component of the data analysis. ... [this] is an invaluable opportunity that should be extended to all prospective secondary science teachers from CU Boulder. It is rare that science teachers have the chance to have a leading role in these aspects of education prior to becoming teachers. ...*

DISCUSSION

Despite increasing national rhetoric on the importance of STEM education and particularly for reaching students from underrepresented populations in the sciences, our formal school systems are not meeting the mark. Simultaneously we are lagging in abilities to recruit and support enough well-qualified pre-college physics teachers. While not a complete solution to either of these significant challenges, university-community partnerships that support informal science education address each of these needs, and do so in a manner that is in the self-interest of the supporting institutions. The mission of most universities seeks to achieve excellence in research, teaching, and service. Providing opportunities for university students to authentically engage in educational practices addresses the latter two components of this mission (and provides a rich area of inquiry for research). Indeed, engaging in community-based educational programs may enhance institutional commitment to teaching and service. Meanwhile, community agencies, be they Boys and Girls Clubs or educational community centers of housing projects, are able to more thoroughly enrich the lives of the youth they serve by offering authentic experiences for children to engage in science. Simply by acting in their own interests, these two institutional structures benefit from collaborating and coordinating. These programs that benefit student and child alike are more likely to be sustained if they are viewed within the core identity of these institutional missions rather than as a convenient or necessary afterthought.

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