Promoting Children's Understanding And Interest In Science Through Informal Science Education

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Abstract. We present results from the University of Colorado's Partnership for Informal Science Education in the Community (PISEC) in which university participants work in afterschool programs on inquiry-based activities with primary school children from populations typically under represented in science. This university-community partnership is designed to positively impact youth, university students, and the institutions that support them while improving children's attitudes towards and understanding of science. Children worked through circuit activities adapted from the Physics and Everyday Thinking (PET) curriculum and demonstrated increased understanding of content area as well as favorable beliefs about science.

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INTRODUCTION

As a result of the No Child Left Behind legislation, general science curriculum in formal settings has been displaced in favor of additional focus on reading and math skills, especially for students in English as a Second Language (ESL) programs. [1] Students are now provided less opportunity to learn science. Furthermore, formal science educational settings face several challenges, including: large student-to-teacher ratios, time constraints, mandated testing, insufficiently trained and under-qualified teachers, and lack of financial and community support. [1-3] While these challenges limit opportunities for all students in science, they disproportionately negatively impact students from under-represented populations. [4,5] To address these challenges, we explore the potential of informal science education (ISE) environments to improve science, technology, engineering, and mathematics (STEM) education for all students.

A recent National Academies of Sciences (NAS) study identified six characteristics of informal learning environments to support the education of youth. [6] These include a variety of characteristics similar to formal environments, as well as opportunities to cultivate science excitement and support the identities of children as contributors to science. While students in formal settings often perceive science lessons as separated from their daily lives, [1] ISE activities are designed to allow students to explore topics directly related to their real-world experiences through play and inquiry. Such opportunities are particularly valuable for under-represented populations who may have difficulty cultivating identities in and favorable attitudes towards science. [7]

Traditionally, out-of-school programs have focused on youth development, whereas informal science research has been largely relegated to museum science experiences. [1] By bringing together community organizers with science professionals, afterschool ISE may positively affect science content knowledge and attitudes by serving as an intermediary space between formal science education, social youth development programs, and museum interventions. [1] Currently, relatively little research in physics education focuses on studying the potential of these ISE environments. While there are increasing numbers of afterschool programs that strive to support K-12 students, only a small body of research describes the potential impacts of after school ISE programs on participating students. [6] We present results on the impact of these ISE programs on children. A related paper [8] presents the potential positive impact that these programs have on the university participants.

A MODEL FOR ISE

The University of Colorado's Partnership for Informal Science Education in the Community (PISEC) [9] afterschool programs follow a university-community partnership model in which university participants (postdocs, graduate, and undergraduate students interested in teaching) partner with community organizers (located in community centers and schools) in afterschool ISE activities. [10] As part of the PISEC program, this study was conducted at Spangler Elementary School in Longmont, CO in a classroom after regular school hours. Two to three university educators (UE's) worked with an average of 13 predominantly Hispanic children in 5th grade for one hour per week, for 7 weeks. The children were selected through registration with the regional Math Engineering Science Achievement (MESA) program, [11] an organization that provides afterschool STEM activities for minority K12 children. A PISEC Fellow (an experienced UE) and an elementary school teacher jointly supervised the site.

The curriculum was modified from the Physics and Everyday Thinking (PET) curriculum [12] to include new educational technologies with inquiry-based basic circuit activities.

A typical session included UEs interacting with small groups of children (~3) who worked through sequential activities. Each part of the activity was passed out separately so that children could work at their own pace. Once finished with an activity, each group was asked to discuss ideas and findings with a UE before receiving the next activity. In these groups, children experimented with light bulbs and batteries and recorded their observations (using pictures or words) in laboratory notebooks. Once the children had finished all activities they made individual or group stop action motion animation [13] movies illustrating learned ideas.

DESCRIPTION

In this study, we investigated children's experience in the program evaluated using pre and post-surveys of their performance on the Conceptual Survey of Circuits (CSC) and the Children's Attitudes Survey (CAS), two components of the PISEC Assessment Suite. These assessments are derived from existing, validated instruments, are being validated for these environments currently, and are described online. [9]

Part 1 of the CSC asked students to draw a working circuit using one wire, battery, and light bulb. [14] The student drawings were scored on a six-point scale, which attempted to cover the main learning goals of the modified PET curriculum, which included comprehension of a complete circuit and the necessity for connecting both bottom and side bulb terminals. For the first rubric category, one point was assigned if the student drew a circuit that expressed some content, did not leave the question blank, and the student attempted an answer using all circuit components. A second point was assigned if the drawing pictured a closed conducting loop, thus expressing the idea of a complete circuit. This point was awarded even if the drawing was not correct. Next, a third point was assigned if the drawing involved connections to both the bottom and side of the bulb. A fourth point was assigned if the student communicated that they knew that the bottom and side of the bulb could be used as connectors. (Many students did not know that the side bulb terminal could be used, while other students drew multiple drawings showing connections to both side *and* bottom bulb terminals.) For the fifth category, one point was assigned if the student's drawing only used one wire, not two. Finally, a sixth point was assigned if the drawing would ultimately light.

Twelve matched pre / post scores were averaged and are shown in Figure 1. The results demonstrate significant positive shifts in content knowledge for the CSC Part 1.

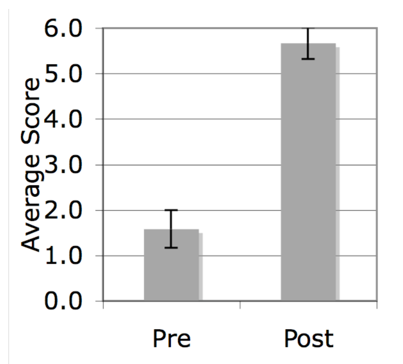

Figure 1. Results for the Conceptual Survey of Circuits (CSC) Part 1. Error is standard error of the mean.

While the CSC Part 1 was administered as both a pre and post-test, Part 2 was only offered as a post-test. This was because the CSC Part 2 was created after the program started, and was designed to test children's ability to extend content material past the point of instruction. The CSC Part 2 was adapted from review PET questions to assess students' conceptual mastery and asked students to predict whether or not each of four circuit drawings would light a bulb, with one point assigned for each correct answer. The average scores for 13 Part 2 surveys and circuit drawings are shown in Figure 2.

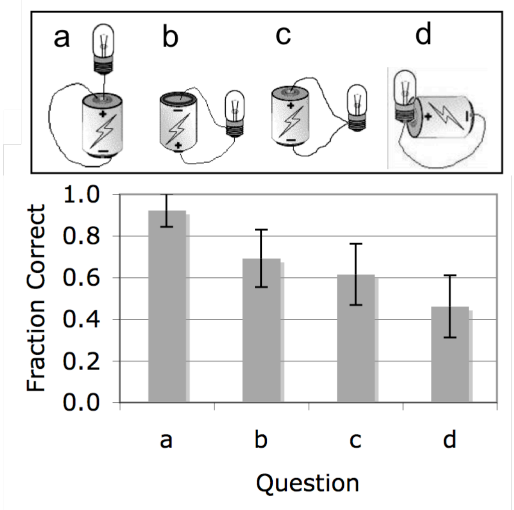

Figure 2. Results for the Children's Conceptual Survey of Circuits (CSC) Part 2. Each of four questions was scored on a 0 (incorrect) to 1 (correct) scale. Error is standard error of the mean.

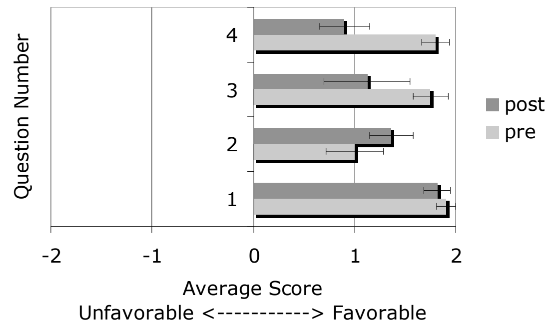

Figure 3. Student attitudes and beliefs (pre / post) as measured by the CAS, on a -2 (unfavorable) to +2 (favorable) scale for the following questions:

1. How do I feel about doing science activities?
2. Do I think there is science in everyday life?
3. Would I like to do an experiment or be told about it?
4. How would I feel about doing science as my job?

An attitude survey, the CAS was adapted for elementary and middle school students from the Colorado Learning Attitudes about Science Survey (CLASS). [15] The CLASS was originally designed to evaluate college student attitudes about science and science learning.

For the CAS, students were presented with four nature of science questions. For each question the students circled one of five statements indicating the degree to which they identified with that question. The statements were assigned Likert-scale values of -2, -1, 0, 1, and 2. Negative values corresponded to unfavorable or novice-like attitudes, while positive values corresponded to favorable or expert-like attitudes. For example, the first question reads "How do I feel about doing science activities?" "Really like them," is a highly favorable, expert-like answer, assigned a value of +2.

Figure 3 shows the matched pre / post scores for the CAS averaged over all students for each listed question. Scores were ignored if the student did not answer or provided multiple answers for a given question, resulting in 11, 11, 8, and 10 matched pre / post scores for questions 1 through 4, respectively. (This response rate is also reflected in the error bars, which are calculated as the standard error of the mean.)

DISCUSSION

The average content gain (gain = post – pre) on Part 1 of the CSC was 4.1 out of 6 points, determined to be statistically significant using a two-tailed t-test with $p<0.01$. All students scored higher on post than pre-test, and all but one student had a perfect score on the post-test for Part 1. After completing the program, children were successfully able to draw a working circuit using only one battery, bulb, and wire. On the 4 questions of the CSC Part 2, students scored an average of 0.92, 0.69, 0.62, and 0.46, respectively out of 1. The decrease in average scores for questions a to d may be coincidental. We note that, in this study, we are limited by small N.

The CAS demonstrated that students generally start with, and sustain, their positive beliefs about science. Two-tailed t-tests indicate only question #4 had a significant shift at the level $p<0.01$. Thus, children experienced no significant shifts on questions 1-3 and a negative shift on question 4. Question 4 asked, "How would I feel about doing science as my job?" It is unclear why students showed negative attitude shifts for this question, although similar results have been observed in other studies with students from similar demographics. [7]. Data from questions 1 through 3 suggests this after school ISE program successfully supported students' favorable attitudes about doing science, seeing science in everyday life, and conducting experiments.

Students were also allowed to comment on the attitude surveys. Some typical post-survey student comments include:

> <u>Comments on Question 1:</u> "What I like about science is that we do a lot of activities that we never made [before]."
>
> <u>Comments on Question 2:</u> "Because you watch TV and that is electricity and electricity is science",
> "Because you do something at your house that you never did."

Comments on Question 3: "I would like to do an experiment instead of being told about it because doing it is more exiting [sic] and I learn about it more",
"Because I can learn from the experiment",
"I would like to try new things that I never did."

Comments on Question 4: "Yes because people would ask me to do different things that's [sic] very cool",
and "Because I also want to teach kids how to do science."

These comments reflect the NAS strands of science learning specific to ISE, illustrating excitement towards and identity in science. For questions 1-3 we did not observe significant attitude shifts. CLASS results in which college students experience no significant shifts are considered desirable. [15] Furthermore, PISEC collected data from another site with similar demographics during three consecutive sessions (spring, summer, fall) which showed average zero shifts during each session, but significant positive shifts over the total time duration. [16] Although the same children participated in these sessions, the curriculum in these sessions was not the same. It is unclear what caused these long-term effects, but longitudinal studies suggest positive attitude shifts may occur over longer periods of time than one semester.

CONCLUSIONS

Data from this afterschool ISE program suggests students developed a greater mastery of content in this ISE environment. Simultaneously, favorable beliefs about science were supported. These measures of content and attitude demonstrate the potential for university-community partnerships to address the calls of the National Academies. Conceptual survey data indicates students developed and used correct models about basic circuits, while their attitude survey remarks express excitement and interest towards science activities. These comments also indicate this afterschool ISE environment allowed students to think about themselves as science learners. While the present study documents the positive impact on children, current studies focus on demonstrating the potential of these environments to improve university students' content mastery, awareness of community-based programs, and their abilities to communicate about science in everyday language. [8,17,18] Future studies will consider what effects afterschool ISE programs have on formal institutions.

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