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Content, Connection and Careers: Kit-Based Learning and Virtual University Connections (Evaluation)

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Abstract

Science kits have been a staple of learning for some time, but in the era of COVID-19 at-home science kits took specific prominence in educational initiatives. In this paper, we delineate how kit-based education can be paired with virtual connection technology to enhance postsecondary and career exploration. The "Content, Connection and Careers" kit-based program has been developed to enable youth to explore electrical engineering principles while connecting virtually with university students to discuss engineering courses and careers. When assembled and wired up, the kit components become linear motors that use a magnetic force to pull a bolt into a pipe when youth press a button. This follows the same working principles as a doorbell or solenoid. These kits are supported by virtual learning sessions where youth connect with university students and faculty to fully understand the educational content, connect to peers and caring adults to share their learning, and explore careers that use electrical engineering skills. To investigate the effectiveness of the program, surveys were distributed to participants to understand whether the kits were simple enough for independent learning but robust enough to encourage additional self-exploration of more difficult topics with the aid of expert scientists and other adult role models. Additionally, youth were asked if the connections made with university faculty and students was beneficial in their thinking of postsecondary options and college engagement.

Over 60 elementary and middle-school aged youth participated in the project. Over 80 percent of survey respondents self-reported improved knowledge of how an electromagnetic field works and how to build a simple electromagnet. Other results showed an increased understanding of engineering careers and courses required to study electric engineering in college. Before their experience in the project, very few of the young people had ever talked to university faculty or university students about their areas of research or their journey into the fields of science, technology, engineering, and math (STEM). This connection was described in the surveys as what the youth liked best about the project.

Introduction

Engaging young people in engineering activities and encouraging them to select a pathway to higher education in the sciences continues to be a high priority in the United States and abroad [1, 2]. Precollege programs are the main way higher education institutions work to inspire young people to pursue engineering education and ultimately a career in the sciences. Many precollege program options use on-campus "camps" or other strategies to bring youth onto the campus to experience STEM curriculum and to connect with faculty, staff, and students. However, there are many limitations to this method including cost [3], transportation from rural locations [4, 5], and more recently, the impact of COVID-19 closing campuses to youth programming. To partially alleviate these limitations, some universities have turned to developing kit-based, hands-on learning modules, where youth receive materials and instructions to learn engineering content.

Kit-based educational initiatives, whether in the classroom or in the home, can have a positive influence on students' learning of engineering concepts [6] [7] and improve STEM interest [8]. Additionally, science content accuracy is highly correlated with the use of kit-based resources when used by elementary school teachers [9], who have limited science content knowledge. Although kits can improve learning and topic interest, they often do not include intentional connection with university students to discuss postsecondary engineering degrees. Informal science learning initiatives with specific and intentional connections to college or university courses, research, and people can impact youth pursuits of higher education in STEM disciplines [10]. Further research has shown that informal science learning is much more impactful if youth are given opportunities to learn while connecting with their peers and adult role models [11] in a meaningful way that supports relationships, experiences, and deeper connection with content [12].

In this paper, we explore the implementation of a kit-based electrical engineering curriculum coupled with virtual connections to the university faculty, student, and staff kit designers. The goals of the Content, Connection and Careers Program implementation were to determine if the kit components and curriculum improved youth's self-reported understanding of electromagnetic principles while helping young people learn about engineering courses and higher education opportunities through authentic connection with university faculty and students. The virtual learning environment allowed the project team to select communities that were unlikely to travel to campus due to economic challenges and geographic settings. A successful kit implementation, which meets the two educational objectives above, could then be adopted and further developed for statewide distribution through the university's Take-n-Learn options supported by the University of Wisconsin – Madison Division of Extension, Positive Youth Development Institute and 4-H Youth Development Program.

Methods

Over 60 elementary and middle-school aged youth participated in the project. Structurally, youth completed the kit curriculum over three weeks with weekly virtual connections with university faculty and students using online videoconferencing technology. Each week, the young people were asked to complete one or two experiments in the curriculum on their own. One-hour virtual connections were held at the end of each week for the youth to ask questions about the content and discuss their successes or challenges. Additionally, there was dedicated time for a University of Wisconsin - Madison undergraduate engineering student to discuss how and why they became interested in engineering as a field of study and what type of career they hope to achieve upon graduation. The university students often showed photos or videos of themselves with engineering projects and discussed courses they found important before and during their college career.

Pre-experience surveys and post-experience surveys, which involved questions related to the understanding of electromagnet systems, higher education aspiration outcomes, and value of the virtual connections, were included in the kit curriculum. The surveys consisted of both open- and closed-ended questions, where the close-ended questions consisted of a 5-point Likert scale. The Likert-type portion of the surveys consisted of nine statements where youth self-reported their understanding by selecting one of the five youth-centric wording options: "No idea," "Sounds a little familiar," "I have heard of it, but don't really understand it," "I have a basic understanding of this," and "Yes, I know a lot about this". Both the pre- and post-experience surveys included the same close-ended questions for comparison. The nine statements on the survey included:

- Ability to understand how a compass works
- Understanding of how electrons move through a circuit
- Knowledge of what an electromagnet is
- Knowledge of where I can find electromagnets in my home
- Ability to build a simple electromagnet
- Knowledge of what type of careers needs and understanding of electricity
- Ability to describe how an electromagnet converts electric energy into magnetic energy
- Understanding of what each part of an electromagnet does in the system
- Understanding of what type of classes are needed to study electronics

The information collected was subsequently converted to nominal data with the number one representing "No idea," the number two representing "Sounds a little familiar," and so on such that the number five represents "Yes, I know a lot about this." This conversion of Likert data to nominal data allows for descriptive statistical analysis to show generalized gains in knowledge and understanding from the pre-experience survey to the post-experience survey. In this case, the data was compiled for each statement and an average was calculated for the pre-experience survey and post-experience survey for comparison. The data also allowed for computing the percentage of youth who responded to having a basic understanding or knowing a lot about a certain concept within the statements. To assess this, numbers four and five from the Likert scale were combined and the frequency percentage calculated, with results from the pre-experience survey compared with the results from the post-experience survey.

The open-ended questions focused on the participants' perceptions of engaging with UW-Madison faculty and students on the videoconferences. The pre-experience survey asked how many young people had ever talked to a college teacher (professor) or university student about science. The post-experience survey explored whether the participants enjoyed this part of the project and why they liked or disliked interacting with the university students and staff.

Results

The nominal data allowed the calculation of a mean score for combined surveys to each survey statement. The number of survey responses totaled 36 at the time of this report. There was an increase in the mean scores of students from the beginning of the experience to the end of the experience for all survey statements. Figure 1 shows the mean results from the survey questions with the most improved gains.

Youth had the greatest self-reported gains in understanding for the ability to build a simple electromagnet (difference of 2.3) and their ability to describe how an electromagnet converts electrical energy into magnetic energy (difference of 1.8). The statement concerning participant's understanding of what each part of an electromagnet does in the system also showed a substantial gain from the pre-experience to the post-experience. Along with these gains in content knowledge, young people also increased their understanding of what type of classes are needed to study electronics in higher education (difference of 1.6).

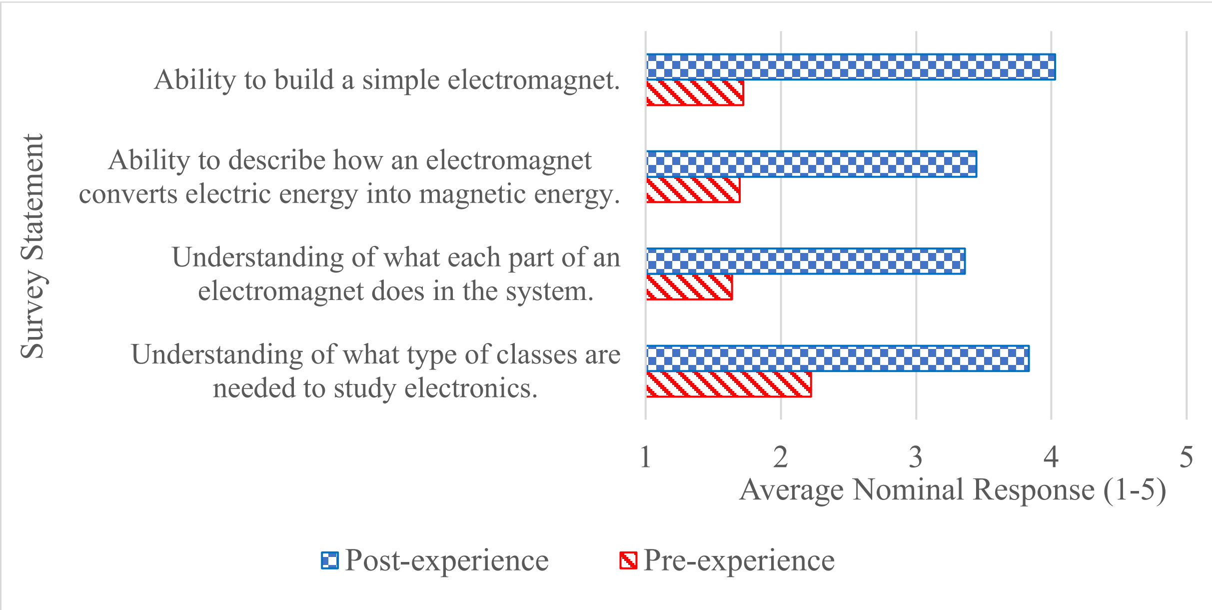

Figure 1: Pre-experience and post-experience average response results (N=36) for the four survey statements with the greatest change.

Results also indicated what type of knowledge participants felt they had prior to their engagement with the Content, Connection and Careers Program. Calculating the percentage of youth responding either "I have a basic understanding of this" or "Yes, I know a lot about this" on both the pre-experience survey and the post-experience survey, one can determine if youth felt if they at least had a basic understanding of the core concepts presented as compared to before the program (Figure 2). The results show that the percentage of youth self-reported understanding of the concepts for all statements before the program experience was substantially lower than that reported after the program. Less than 20 percent of respondents reported a basic understanding of concepts presented in six of the nine statements, including understanding of what type of classes are needed to study electronics. The statements that showed a greater than 60 percent gain in respondent understanding were: "Ability to build a simple electromagnet" (67% change) and "Knowledge of what an electromagnet is" (64% change).

The data also show that less than 50 percent of the youth felt that they had a basic understanding of how electrons flowed through a circuit after the project. This indicates that the curriculum could be improved by adding an activity or explaining this concept in a more complete way.

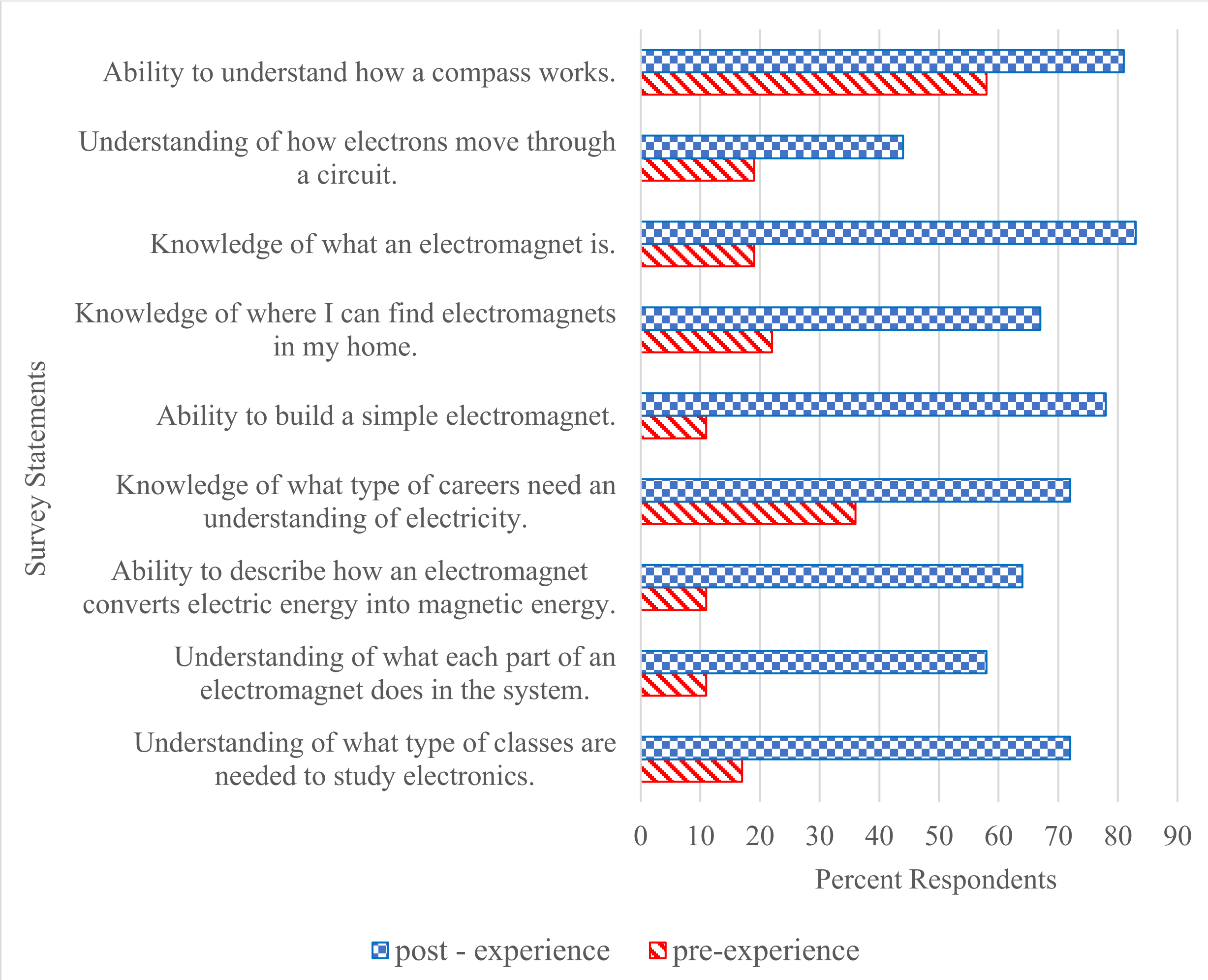

Figure 2: Results of the combined Likert responses of "I have a basic understanding of this" and "Yes, I know a lot about this" for the pre-experience survey responses compared to the post-experience survey responses for all statements. N = 36.

The open-ended questions on the pre-experience survey and post-experience survey were used to help one understand if youth had previously engaged with university faculty or students about a science project and if the participants found these interactions valuable. Ninety-four percent of the 36 participants who answered this question indicated that they had never talked to a university faculty or student about a STEM project. However, 92 percent of respondents felt this interaction was valuable. When asked why they liked the virtual connections with university students, seven out of the 16 youth who responded to this question stated in some way that they liked how the university students talked about how they got involved with engineering and the University of Wisconsin – Madison. Other responses included several students saying that the university students were fun to learn from and the engagement helped them understand the project better.

Discussion and future work

There is no replacement for face-to-face, on campus, precollege experiences to expose young people to postsecondary education opportunities. However, the reach of precollege programs can be broadened by providing authentic virtual connections to university research, faculty, and students, while engaging them in hands-on experiments. In this work, university faculty and staff created an independent learning kit focused on electromagnets. The kit curriculum was evaluated to understand if youth could successfully complete the experiments and gain understanding of what an electromagnet is and how it works to convert electric energy into magnetic energy to do work. The participants connected each week, over a three-week period, with the kit developers to share experiment challenges, successes and to ask questions. This type of interaction, where the videoconferences were for discussion purposes as opposed to teaching sessions where youth were led through the experiments, provided an authentic connection among the participants and the university students and faculty as scientist peers instead of an instructor – student interaction.

Data collected from pre-experience and post-experience surveys indicated that the kits were successful in improving participants self-reported understanding of the fundamental concepts of an electromagnet. Information gathered suggested students had not previously explored electromagnetism as an energy source but were familiar with magnetic fields as described by their understanding of how a compass functioned. The kit and corresponding curriculum allowed the youth to explore the experiment on their own and successfully complete the activities. Additionally, the participants noted that they had a better understanding of coursework they would need to take to pursue a degree in electronics.

The virtual connection component of the project enabled youth to discuss the kit experiments with university students and staff, which was a new experience for most of the youth surveyed. The young people described these interactions as helpful both in understanding the kit content and expressed an interest in hearing the university students' journey into the engineering field. Based on the results collected, the kit will be added to the collection of Take – N – Learn offerings through the University of Wisconsin – Madison Division of Extension Positive Youth Development Institute. In this way, the kit will be further evaluated and adapted for statewide distribution through the 4-H Program. Follow-up surveys are in-process to understand the longer-term knowledge retention of the curriculum and impact of the university virtual engagement.

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