Implementation of Project Based Learning in an After School Program

Dr. Afrin Naz, West Virginia University Institute of Technology

Dr. Afrin Naz is an assistant professor at the Computer Science and Information Systems department at West Virginia University Institute of Technology. She is working with high school teachers to inspire the K-12 students to the STEM fields. In last four years Dr. Naz and her team launched six workshops for high school teachers. Currently her team is training the high school teachers to offer online materials to supplement their face-to-face classroom.

Ms. Jordan Nicole Bowen,

Jordan Bowen is a student majoring in Computer Science and minoring in Mathematics at West Virginia University Institute of Technology. She will be receiving her bachelor's degree on May 4, 2019. Jordan has been a part of a number of projects focused on improving k12 teacher quality and sparking an interest in STEM in k12 students. She is also the leader of three NCWIT-sponsored camped aimed at middle school girls in hopes of inspiring them to join computing-related fields.

Mardigon Max Toler, West Virginia University Institute of Technology

Mardigon Toler is a student of Computer Science and Mathematics at West Virginia University Institute of Technology, finishing a bachelor's degree in both fields in spring 2019. His interests include digital audio, digital signal processing, and distributed and parallel computing. His past projects have included applications of AI to real-time music accompaniment as well as real-time software-based audio synthesis using Fourier transforms.

Dr. Mingyu Lu, West Virginia University Institute of Technology

Mingyu Lu received the B.S. and M.S. degrees in electrical engineering from Tsinghua University, Beijing, China, in 1995 and 1997 respectively, and the Ph.D. degree in electrical engineering from the University of Illinois at Urbana-Champaign in 2002. From 1997 to 2002, he was a research assistant at the Department of Electrical and Computer Engineering in the University of Illinois at Urbana-Champaign. From 2002 to 2005, he was a postdoctoral research associate at the Electromagnetics Laboratory in the University of Illinois at Urbana-Champaign. He was an assistant professor with the Department of Electrical Engineering, the University of Texas at Arlington from 2005 to 2012. He joined the Department of Electrical and Computer Engineering, West Virginia University Institute of Technology in 2012, and he is currently an associate professor. His current research interests include wireless power transmission, radar systems, microwave remote sensing, antenna design, and computational electromagnetics. He was the recipient of the first prize award in the student paper competition of the IEEE International Antennas and Propagation Symposium, Boston, MA in 2001. He served as the chair of Antennas and Propagation Society of IEEE Fort Worth Chapter from 2006 to 2011.

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Introduction

In this paper we talk about integrating project-based learning into various teaching settings in Raleigh County middle and high schools, through after-school programs. As a teaching methodology, project-based learning employs projects closely associated with real-world applications to facilitate teaching abstract math and science concepts. Enormous prior research has generated encouraging evidence demonstrating that project-based learning succeeds in increasing students' content knowledge, enabling students to transfer knowledge to practical implementation, promoting students' collaboration skills, and developing students' positive attitudes towards math and science [1-5]. When project-based learning is used to supplement instructions, students are inspired to pursue STEM (science, technology, engineering, and mathematics) careers [4].

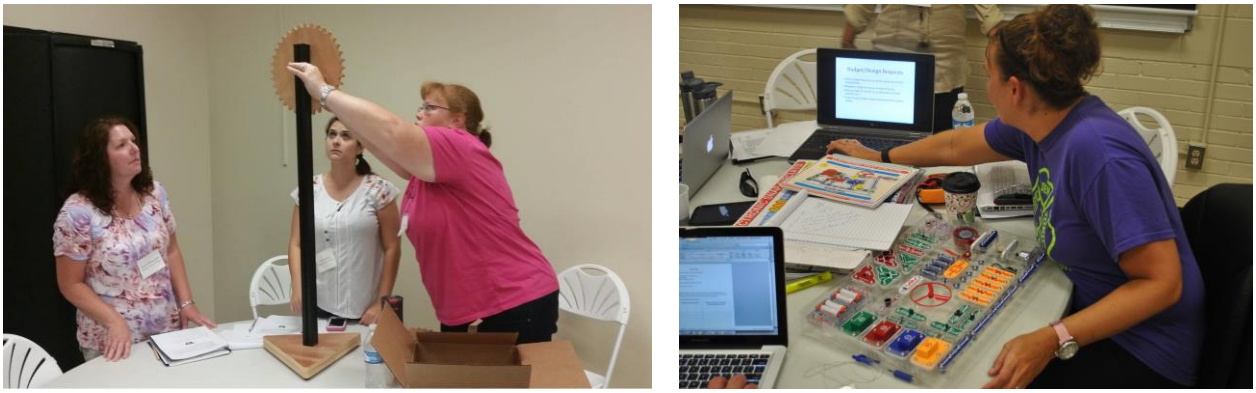
In the summers of 2015, 2016 and 2017, we organized workshops on the West Virginia University Institute of Technology (WVU TECH) campus for math and science middle and high school teachers to learn project-based learning systematically. Workshop instructors are WVU TECH computer science and engineering faculty members. Sample computer science and computer engineering projects were demonstrated to the teachers. The teachers also conducted hands-on exercises to develop computing projects to address certain content standards, following the protocol established by the West Virginia Department of Education [6].

On September 2018, these middle and high school teachers have started to pilot the after-school programs in three middle schools and one high schools of Raleigh County. It is expected that the widespread application of project-based learning will improve the math and science education of Raleigh County, and furthermore, would inspire more students to pursue careers in STEM disciplines. We have total eight undergraduate West Virginia University Institute of Technology students in STEM fields assigned to provide year-round onsite and online assistance to these teachers. An extended budget item has been allocated for teachers to purchase hardware and/or software for project-based learning. Currently we are collecting data through online survey. It is estimated that at least 500 students will be impacted by these methods within the next two years throughout Raleigh County.

Related work

The underlying principle of this after school program is *project-based learning*, which is grounded in scientifically-based research. Specifically, project-based learning employs projects

closely associated with real-world applications to facilitate delivering abstract math and science concepts [1]. Enormous prior research has generated encouraging evidence demonstrating that, project-based learning succeeded in increasing students' content knowledge, enabling students to transfer knowledge to practical implementation, promoting students' collaboration skills, and developing students' positive attitudes towards math and science. For instance, according to Frank *et al*., students found that the project-based format motivated students to learn and made them feel a greater sense of responsibility for their learning [2]. As another example, it was concluded by Schachterle and Vinther that, students were inspired to learn actively through open-ended projects as they appreciate the usefulness of knowledge in textbooks [3]. Moreover, when project-based learning is used to supplement instructions, students are inspired to pursue STEM careers [4]. In 2012, the Office of Research of West Virginia Department of Education conducted a research on the effect of project-based learning; its report shows that, teachers who received extensive training on project-based learning were capable of teaching the 21st Century Standards more effectively compared with teachers without experience on project-based learning [5].



(a) Teachers conducting mechanical engineering projects (b) Teachers conducting electrical engineering projects

Figure 1: Two photos of our workshop in Project Based Learning.

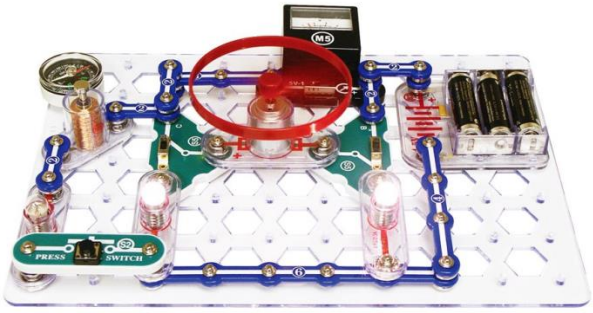
We have organized three workshops with project-based learning as the theme to high school and middle school teachers in 2015, 2016 and 2017, respectively. Our workshops followed the project-based learning framework designed by West Virginia Department of Education [6]; specifically, the participating teachers learned designing projects, mapping projects to content standards/objectives, and assessing the outcome of project-based learning. Two photos taken at our workshop are shown in Figure 1. In Figure 1(a), a group of teachers were conducting a mechanical engineering project. In Figure 1(b), the participating teachers were constructing circuits in the electrical engineering session. Surveys collected from our workshop participants indicate that the workshops were well received by the participating teachers. For instance in a survey after the workshop in 2016, the participating teachers were asked "did the workshop increase your knowledge and skills relative to the topic presented?"; out of the 21 teachers who completed the survey, 10 answered "very well", 11 answered "moderately", and none answered "somewhat" or "not at all." After each summer workshop, we had follow-up meetings with the

participating teachers, and the teachers presented their implementation of project-based learning as well as the outcome of implementing project-based learning. All the school districts that partnered with us in the past two years are highly satisfied with the workshops' outcome, and all of them encourage us to offer training of project-based learning to more of their teachers.

This project is largely motivated by the collaborative relationships established through our past programs. In December 2017, we submitted a grant request to a local Foundation, the Carter Family Foundation. It was approved by the Carter Family Foundation in January 2018. The project aims to promote project-based learning in the middle schools and high schools of Raleigh County. Our implementation started immediately after the grant request was approved.

Program Implementation

In the Spring semester of 2018, Raleigh County Schools and West Virginia University Institute of Technology jointly identified three middle schools (i.e., Park Middle School, Beckley Stratton Middle School, and Independence Middle School) and one high school (i.e., Independence High School) of Raleigh County to initiate pilot programs. In the summer of 2018, we had extensive meetings with about 15 teachers of these few schools. In the Fall semester of 2018, 12 teachers initiated after-school programs on project-based learning. Eight undergraduate students of West Virginia University Institute of Technology provided assistance to the teachers. More than 90 middle school and high school students participated in the after-school programs in the Fall semester of 2018. This paper summarizes the activities and outcome in the Fall semester of 2018. The after-school programs will be resumed in the Spring semester of 2019.



Electrical engineering projects are based on Snap Circuits Hardware Kits (http://www.scientificsonline.com/shop/science-kits/electric-kits). Using these low-cost kits, students can snap components (i.e., without soldering) to build circuits and then measure various circuit quantities.

Mechanical engineering projects are based on Gear Kits. Using this kit, students learned about ratio and geometric operations

Figure 2: Illustration of sample projects in electrical and mechanical engineering

The sample projects are classified into three categories: electrical engineering, mechanical engineering, and computer programming. The sample projects do not require expensive components, so that they can be readily applied in the after-school programs. Meanwhile, all of them are designed to address certain math and science standards and objectives. Our sample projects of electrical engineering and mechanical engineering are illustrated in Figure 2. The Snap Circuits Hardware Kits in Figure 2 allow students to visualize and transform various circuit quantities (such as voltage, current, and resistance), thus can be directly mapped to science objectives. Using a gear kit (depicted in Figure 2) to work with gear ratios would help students to understand ratios and geometry, and thus would greatly facilitate addressing certain math objectives.

Most of the after-school programs in the Fall semester of 2018 were held on Tuesdays in Fall 2018, as illustrated by the table below.

Table 1: Four sessions rotated among the four participating schools

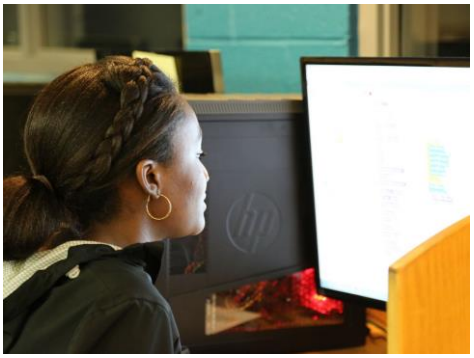
Middle School	Middle School	Middle School	High School
Summit	Science	Math	Computer
Computer	Summit	Science	Math
Math	Computer	Summit	Science
Science	Math	Computer	Summit

As shown in the table above, four sessions were rotated among the four participating schools. The four sessions were decided jointly by Raleigh County Schools and West Virginia University Institute of Technology: (i) math, (ii) science, (iii) computer programming, and (iv) visit to the Summit Bechtel Family National Scout Reserve. We greatly appreciate the Summit Bechtel Family National Scout Reserve offering us their world-class facilities without any charge for arranging STEM related outdoor activities.

Some of the activities of the after-school programs are demonstrated by several photos in Figure 3. Figure 3(a) shows the math session: students were using gear kits to understand certain mathematical concepts. The photo in Figure 3(b) was taken when students were building circuits in the science session. A snapshot of computer programming session is shown in Figure 3(c). In the photo of Fig. 1(d), teachers and students visited “tree house” of the Summit Bechtel Family National Scout Reserve.

(a) Math session

(b) Science session



(b) Computer programming session

(d) Visit to Summit

Figure 3: Activities during the Fall semester of 2018.

Results

The middle school and high school students who participated in the after-school programs were constantly asked to complete online surveys, for the program organizers to assess the effectiveness of the projects. Some of the survey results are presented Figures 4, 5, and 6 below. The survey results unequivocally indicate that the projects are well received by the participating students.

In Figure 4 we can see that when asked the question "how did you enjoy the class today", 69% of 348 responses was excellent and 21% was very good. Figure 5 demonstrates that 48% times the students rate their learning excellent and 27% time as very good. Finally, in Figure 6 we can see that 95% times the participants answered yes when they were asked "Would you recommend a program like this to a friend".

Figure 4: Survey results of "how did you enjoy the class today?"

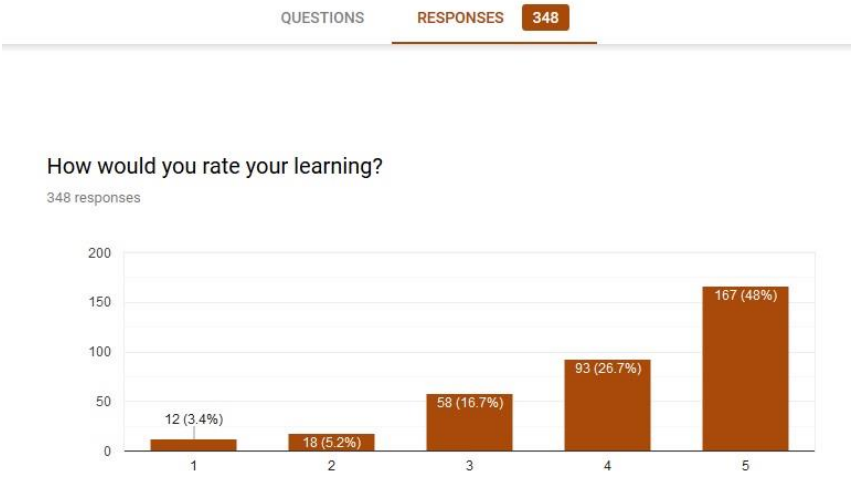


Figure 5: Survey results of "how would you rate your learning?"

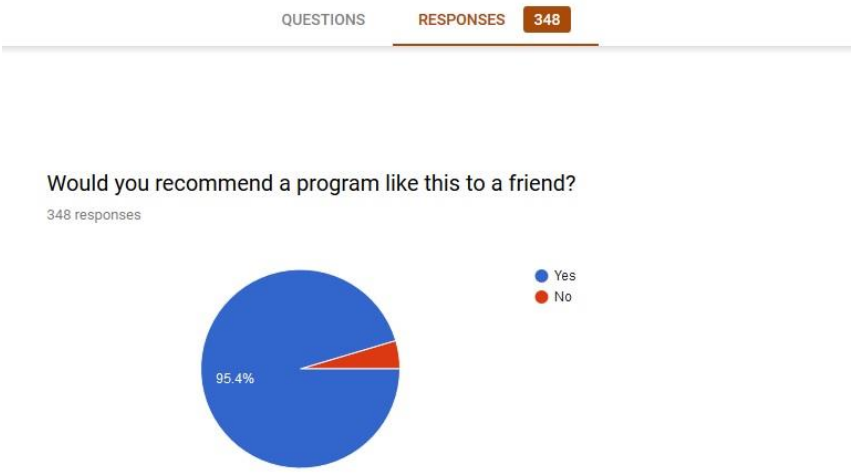


Figure 6: Survey results of "would you recommend a program like this to a friend?"

Conclusions

On November 26th, a ceremony was held at West Virginia University Institute of Technology University to celebrate the success of the pilot after-school program. Three groups of middle school students demonstrated what they learned from the after-school program. Administrators of West Virginia University Institute of Technology University (including Campus President Dr. Lang), administrators of Raleigh County Schools (including Superintendent David Price), and representatives from the Carter Family Foundation attended the ceremony. The ceremony was reported by local TV and newspapers. The after-school programs will be resumed in the Spring semester of 2019, with robotics as the most important addition.

Acknowledgment

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