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Engaging Engineering Students in Experiential Learning through Robot Droids and K-12 Outreach

Dr. Joshua Montgomery, THE Ohio State University & Southern State Community College

Dr. Joshua Montgomery is a Computer Science Professor at Southern State Community College, a Senior Lecturer at The Ohio State University, and an AI instructor at Southern New Hampshire University. With over a decade of experience as a professor and 13 years as the Technology Director for Chillicothe City Schools, Montgomery has been deeply involved in education and technology leadership. He serves as Co-Director of the Ohio Code Scholar program, an initiative by the Ohio Department of Higher Education aimed at developing electronic and coding skills for K-12 students in southern Ohio.

Montgomery is the inventor of the STEM MiniDome and Wearable Droid teaching robots, tools used to teach electronics and coding to students. An active member of the Star Wars droid builder community, Montgomery built a full-scale replica of R2-D2, a project that took 2.5 years to complete. His experience with this project transformed his teaching approach, a topic he discussed in his TED Talk in Dayton, Ohio, in 2021. Montgomery is also the cofounder of SOMACC (Southern Ohio Makers Against COVID Coalition), a grassroots group that produced 4,500 3D-printed face shields for first responders at the onset of the COVID-19 pandemic.

Amy Perkins-McClellan, Southern State Community College

Amy Perkins-McClellan is a professional in higher education having managed grants and special projects for 12 years at a rural community college in Southern Ohio. With a background rooted in both manufacturing, project management, and education, she has consistently demonstrated her ability to drive innovative solutions, execute projects, and lead successful teams. Amy combines her technical proficiencies with a commitment to fostering growth and collaboration in all areas of work. Over the years, she has worked on grants, student success, retention, project management and execution, community outreach, and program planning. Over the years, she has worked hard to be recognized as a leader in excellence and impact in a rural setting. Mrs. Perkins-McClellan serves as the Co-Director of the Ohio Code Scholar program, an initiative by the Ohio Department of Higher Education that is aimed at developing electronic and coding skills for K-12 students in southern Ohio.

When not immersed in her professional pursuits, Amy enjoys watching her daughter play competitive softball, golfing, and cruising, reflecting on her well-rounded and compassionate approach to life.

Dr. Ayanna Howard, The Ohio State University

Dr. Ayanna Howard is the Dean of Engineering at The Ohio State University and Monte Ahuja Endowed Dean's Chair. Previously she was the Linda J. and Mark C. Smith Endowed Chair in Bioengineering and Chair of the School of Interactive Computing at the Georgia Institute of Technology. Dr. Howard's research encompasses advancements in artificial intelligence (AI), assistive technologies, and robotics, and has resulted in over 275 peer-reviewed publications. She is a Fellow of IEEE, AAAI, AAAS, and the National Academy of Inventors (NAI). She is also an elected member of the American Academy of Arts and Sciences and recipient of the Richard A. Tapia Achievement Award and NSBE Janice Lumpkin Educator of the Year Award. To date, Dr. Howard's unique accomplishments have been highlighted through a number of other public recognitions, including being recognized as one of the 23 most powerful women engineers in the world by Business Insider and one of the Top 50 U.S. Women in Tech by Forbes. In 2013, she also founded Zyrobotics, which developed STEM educational products to engage children of all abilities. Prior to Georgia Tech, Dr. Howard was at NASA's Jet Propulsion Laboratory where she held the title of Senior Robotics Researcher and Deputy Manager in the Office of the Chief Scientist.

Engaging Engineering Students in Experiential Learning through Robot Droids and K-12 Outreach (Evaluation)

Abstract

In this full evaluation paper, we discuss a study that examines the impact of two experiential learning programs on both engineering students (as teachers) and K-12 students (as learners) aimed at enhancing STEM education. The two programs focused on providing hands-on engineering experiences by having students build custom 3D-printed robots that taught them a wide range of skills in electronics and coding. The first program, STEM MiniDome, involved engaging students in building a 50% scale model of an R2-D2 dome from Star Wars. The second program, Robot Wars, involved custom-designed robots that students could modify and 3D print, culminating in team competitions at the end of the school year. These custom 3D-printed robots provided the initial buy-in and engagement for both student teachers and learners as the student cohorts navigated through a series of 19 lessons they completed throughout the academic year at the K-12 school. At the end of the school year, a celebration-day event was held where students showcased their projects and were recognized for their results and creativity. The findings from this study illustrate that the programs effectively address the challenge of having STEM K-12 educators become more comfortable teaching engineering concepts and the skills associated with engineering by directly involving college professors and students in the K-12 teaching cycle. The collaboration enhances the educational experience for K-12 students, helping them develop essential skills such as problem-solving, critical thinking, and creativity. Survey results indicate that high school students, after participating in the program, were more likely than the national average of STEM high school students to have an interest in exploring a career in computer science. These results (40% versus 11%) suggest that the program fosters a pipeline of future innovators and problem solvers while building a stronger community with a well-educated workforce capable of addressing local needs. This study also highlights the positive impact on college students, as they enhance their skills through mentoring and guiding younger learners, cultivating their confidence around the social impact engineers can have in the community.

Introduction

Although engineering has been a major discipline since the 18th century, many students still do not understand the full breadth of problems engineers solve. Studies continue to highlight common misconceptions about engineering work including gender stereotypes about engineering and erroneous concepts about the nature of the engineering profession [1][2][3]. Unfortunately, these misconceptions are driving the U.S. towards a large talent gap such that the number of engineering jobs that need to be filled in the future will outpace the number of engineering degrees awarded [4].

For those students who eventually decide to pursue engineering, studies have indicated that when high school students, especially first-generation students, choose engineering, their reasons range from having a curiosity and interest in the subject matter, being influenced by a family member, or prompted based on a financial motivation [5, 6]. These pre-engineering students then matriculate into college without a full understanding of the engineering discipline, the impact engineers have on solving societal problems, or the impact they themselves could have with their engineering skill set. Unfortunately, the graduation rate for engineering students in the U.S. has not budged much over the past decades, with the attrition rate from engineering surpassing that of most other majors [7]. Studies though have shown that when students are involved in co-curricular activities, such as internships, undergraduate research programs, and learning communities, retention does improve. Co-curricular activities, which take place outside of the classroom setting, not only helps reinforce the theoretical concepts taught in class, but it can provide hands-on experiences that showcase the value of engineering in solving real world problems.

As such, we decided to capitalize on the positive impact co-curricular experiential learning can have on engineering students (as teachers) and utilize it as a tool to also enhance the educational experience for K-12 students through project-based learning. We discuss our experiential learning programs which were developed as a partnership between local K-12 schools and colleges. The programs outlined in this study show how hands-on opportunities connect practice to theory. The two programs outlined in the paper utilize custom 3D-printed robots to engage K-12 students and teachers. They provide a custom curriculum that is engaging and fun while supporting the K-12 teachers and students by involving college professors and students. These programs foster creativity and critical thinking while developing a pipeline of future engineers.

Project Approach

In 2021, through funding from the state of Ohio, the Ohio Code Scholar Program was born [8]. The innovation of this program was the engagement and partnership of local colleges with local K-12 school districts. By involving colleges directly in the interaction, the Ohio Code Scholar Program could provide access to resources that the K-12 school district may not have access to [9]. These resources were not just equipment or state-of-the-art technology. The expertise of the college faculty and students also provided K-12 schools with access to knowledge sets that could be lacking in the K-12 school district.

The Ohio Code Scholar program's audience focused on under-resourced schools in Ohio, such as those considered rural and/or designated as Appalachian. The selected schools were chosen based on existing partnerships between higher education and secondary institutions, including College Credit Plus collaborations, advisory board memberships, and other program connections. Participation required only adherence to a simple Memorandum of Understanding, granting schools access to technical support and equipment. Each school determined its implementation approach, integrating the project into a single class, an entire grade level, or an after-school club. Teachers incorporated the curriculum into their lesson plans throughout the school year, tailoring it to their instructional needs.

The schools in these focused areas often face distinct challenges and opportunities influenced by their environment, culture, and community. Many grow up with a generational emphasis on staying with community and family upon graduation from high school [10]. These students often base their futures on higher education and career pathways on those family expectations [6].

Further, many are first-generation students whose parents never encouraged furthering their education or skills because of the unfamiliarity with college and its processes [11].

The experiential learning programs discussed in this paper highlights two years of college partnerships with K-12 schools deployed under the Ohio Code Scholar Program. During this two-year cycle, a year-long STEM curriculum was designed and deployed in order to expose students in grades 4 through 12 to core engineering topics. Research has shown that K-12 schools face numerous challenges, including the ability to hire a sufficient number of STEM educators that are comfortable with teaching engineering concepts and covering the broad range of skills associated with engineering-related topics [12]. This can be particularly challenging for low-resourced communities. The Ohio Code Scholar Program aimed to address these challenges by structuring experiential learning programs such that K-12 STEM educators received direct support from a local college. Teachers receive training to implement engineering projects effectively, while college students assist by visiting classrooms to provide support. This model enhances the educational experience for K-12 students, helping them develop essential skills like problem-solving, critical thinking, and creativity. The initiative also strengthens college students' skills by allowing them to mentor and guide younger learners [16]. Ultimately, the program fosters a pipeline of future innovators and problem solvers, building a stronger community with a well-educated workforce capable of addressing local needs. This study will allow us, in the future, to begin assessing whether college students' perception towards their own engineering curriculum changes based on their own experience teaching K-12 students.

To increase engagement and buy-in, engineering projects were intentionally constructed to maximize hands-on learning through lessons designed around 3D-printed robots. The STEM MiniDome, shown in Figure 1, and the Robot Wars project, shown in Figure 2, both used the Arduino Uno as the controller to operate their systems. Teachers had the option to use either C++ or Arduino Block coding for their students. The STEM MiniDome has a 9-inch diameter, while the Robot Wars project had no size restrictions, however, the robots could not exceed 2 lbs. in weight.

Figure 1
STEM MiniDome examples built by the students

Figure 2

Robot Wars project examples built by the students


The STEM curriculum associated with these two programs (STEM MiniDome and Robot Wars project) was ultimately crafted to enable students to learn electronics and robotics through a series of 19 lessons, all while working with a robot they designed themselves. The prints for the MiniDome took the longest, each side of the MiniDome took about 12 hours. The Robot Wars frame took much less time, around 4 hours in total. To facilitate the 3D printing process, the teachers were supplied an approved 3D printer for their classroom. If the class size exceeded 50 students, we would approve additional printing resources. The lessons for the STEM MiniDome project are outlined in Table 1 below. Each teacher and student are given a detailed guide with instructions and videos on how to complete the project. Table 1 shows the 19 lessons they will follow as they move through the process of 3D printing their dome, painting it, installing electronics and coding the robot to perform a series of actions with 3 buttons operating two motors, 3 lights and a series of sounds. Students are encouraged to add more operations to be unique. One student in the program made his dome smoke, intentionally, replicating a feature of a well-known pop culture robot. Having a student connect to a project they love due to a pop culture connection or idea they own is the hook, and it cannot be understated how important that hook is for buy-in and engaging a student [13].

Table 1

STEM MiniDome Lessons Plan Overview

#	Lesson Title	Activity Summary	Objective	Time to Complete
1	Print Domes	3D prints the 2 main dome parts.	Students will learn about how to 3D print.	24 to 48 hrs.
2	Print Bits and Bobs	3D prints all the pieces needed for the hinge and controller	Students will learn about how the 3D parts are printed and supported.	4 hrs.

3	Prep / Sand	Using a tool clean up the 3D prints and sand any part that will need painted.	Students will learn how to prepare a model to remove the 3D printed lines to make a model look perfect.	1 hr.
4	Primer Dome	Paint the 2 main dome parts and 2 pie plates a primer.	Students will learn the basic functions on how to use a rattle can spray can.	1 hr.
5	First Base Coat	Paint the 2 main dome parts and 2 pie plates the first base coat.	Students will design their paint scheme and apply the first base coat to the dome.	1 hr.
6	Tape off Dome	Mask off sections on the parts not needing the final paint coat.	Students will learn how to mask a dome for a two-stage printing process.	1 hr.
7	Top Coat / Touch Up	Apply final paint coat, remove masking tape and touch up any sections necessary.	Students will apply the final coat of paint, remove tape and touch up the model.	1 hr.
8	Arduino Setup	Install the Arduino into the Dome.	Students will glue the Arduino into the dome and go over what a microcontroller can do.	1 hr.
9	Breadboard / LEDs	Install Breadboard into Dome and LEDs into the holo-projector.	Students will learn about how a breadboard works, learn how to turn on LED by completing a circuit using the breadboard and the installed LEDs.	1 hr.
10	Basic Coding	Teach students the basics coding using the programming language selected for the project.	Students will learn about loops, variables, and functions in the Arduino code environment.	1 hr.
11	Code the Light	Blink all 3 LED lights using the programming language selected for the project.	Students will learn how to blink all 3 LED lights in different sequences using the Arduino code.	1 hr.
12	Hinge and Motors	Assembly servo hinges and attach to the dome.	Students will learn about motion and geometry of hinge movement.	1 hr.
13	Code the Motors	Move the 2 motors in the dome using the programming language selected for the project.	Students will learn how to move both motors using the Arduino code.	1 hr.

14	Finalize Assembly	Install the speakers, MP3 player and connect the domes together.	Students will finalize the wiring and assembly of the dome by installing the speaker, mp3 players, magnets and connecting the domes using a piece of 3d printer filament.	1 hr.
15	Load MP3 Files	Load MP3 files to be played inside the dome.	Students will load MP3 files to be played through the dome. This can be custom files or ones included in the build guide.	1 hr.
16	Code the Sounds	Play all sound sequences using the programming language selected for the project.	Students will learn how to play all the different sound files that are loaded to the MP3 player using code.	1 hr.
17	Wire up the Controller	Install the controller with 3 buttons and wired up to the dome.	Students will assemble the controller, and install it within the dome.	1 hr.
18	Code the Buttons	Program 3 buttons to develop a sequence in using the programming language selected for the project.	Students will learn how to code 3 buttons to blink lights, move motors and play sounds.	1 hr.
19	Custom Code	Develop a sequence to play after a button press	Students will develop a sequence to take place when a button is pressed. Pressing 1 button should perform a variety of functions (move motors, play sound, blink lights).	1 to 4 hrs.

When a college agrees to mentor a local K-12 school, a college-designated professor, during the prior summer, focuses on building the project and developing the curriculum for the participating schools. Each project is different, but designing the 3D printed project and developing the curriculum took about 3 months for each project. The professor would go through multiple 3D designs to make sure the robot was functional and inclusive. Once constructed, the program begins training K-12 teachers on the full scope of the project, ensuring they are familiar with the expectations and objectives for the upcoming year. In the fall, the college professor hires college students to assist by visiting schools and supporting the teachers. Necessary supplies, such as electronics and 3D printers, are procured and distributed to each school. Each teacher in the Ohio

Code Scholar program is given a 3D printer, and all supplies is funded through the grant. At the end of the fall semester, a check-in meeting is conducted with the K-12 teachers to address any issues and assess their progress. While communication is maintained via email throughout the semester, this meeting serves as a required in-person check-in.

During the spring semester, the professor continues supporting the teachers, culminating in a celebration event. College students play a crucial role in the schools during this time, providing hands-on assistance, and performing check-ins with the teachers each month. At the end of the spring semester, all schools come together for a final celebration day, including a competition, where awards are given, and both successes and challenges are recognized. The students are celebrated at this event as promising engineers. While everyone receives a certificate of completion, some individuals are recognized with trophies and medallions for excelling in categories such as “Best in Show”, “Best Operations”, “Crazy Cabling”, and “Best Paint Job”. During the closing ceremony, students are announced by name and invited to the main stage to receive their plaque or crystal award. Their projects are evaluated using a rubric designed to align with the project’s objectives, which secondary teachers receive at the start of the second half of the program. Approved partners or project directors then review the submissions based on these criteria. Throughout the event, students participate in sessions exploring various engineering fields and engage with industry leaders and, at times, celebrities. In the project's first year, large Star Wars props, managed by members of the Droid Builders community, were featured to enhance student engagement. Teachers and students are also given a survey at the end of the ceremony to evaluate the celebration and project. The information gathered in the outcomes section come from this survey.

The event is also designed to bring in local industry experts and community partners to further strengthen the bond between the K-12 students and the community they were engaging in. The partnership with the community continues to grow as does their involvement. The level of involvement ranges from national hobbyist, some who found their way into employment with Pixar, to larger corporations within the region and state coming to either view the celebration or provide learning sessions to the students. Nurturing those relationships with industry partners, state legislators, county commissioners and councils, aims to put the project in a space that can be sustained past the funding limits.

Results and Discussion

The program has seen significant growth and positive outcomes over the past two years. While the MiniDome program in Year 1 had a smaller reach, it garnered overwhelmingly positive feedback from participants. Many students reported significantly improving their coding skills and expressed a strong interest in exploring computer science careers.

In Year 2, the program expanded by incorporating the Robot Wars project in order to reach more students. Despite the increased scale, the program maintained a high level of satisfaction among participants. The survey results indicate that most students found the program a great experience and reported improved coding understanding.

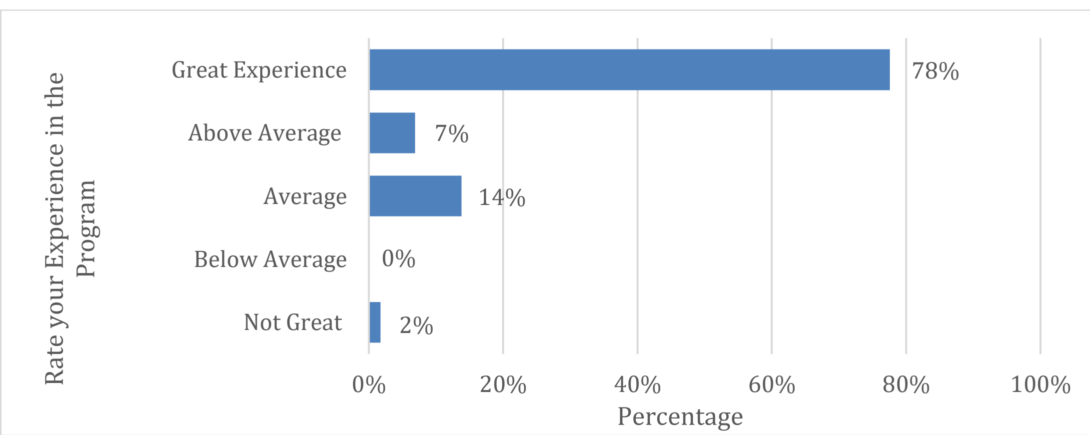
The programs have successfully engaged students and fostered a positive learning environment. The increasing number of students interested in pursuing computer science careers is a testament to the program's effectiveness in inspiring the next generation of technologists. The national average of STEM graduates from high school that study computer science in college is 11% [14]. In this program, 48% in year one and 41% in year two said they would explore a career in computer science. This is a drastic increase and further shows the program's impact.

Ohio Code Scholar Year 1: STEM MiniDome project outcomes

In the first year of the Ohio Code Scholar program, 100 students from 6 schools participated in the STEM MiniDome project. One college professor built the project and over saw the curriculum for the 8 teachers in the program. The teachers were assisted in their classroom by the professor or the college students during scheduled times. The teachers had a build guide that was developed by the college professor with videos explaining the project. The college students, three of them, would rotate to different K12 classrooms based on need. This program involved professors, staff and college students from Southern State Community College. These students successfully completed over 19 STEM lessons and constructed 72 domes. To gauge the program's effectiveness, 58 participants were surveyed.

Question 1 asked the students to rate their experience in the program. The survey results were overwhelmingly positive. Most students (84%) rated their experience in the program above average, with 78% describing it as a "great experience." Only a small percentage (2%) expressed dissatisfaction, indicating that the program resonated well with most participants. Figure 3 illustrates these results, with only reported responses shown in the figure.

Figure 3
Rate your Experience in the Program – STEM MiniDomes

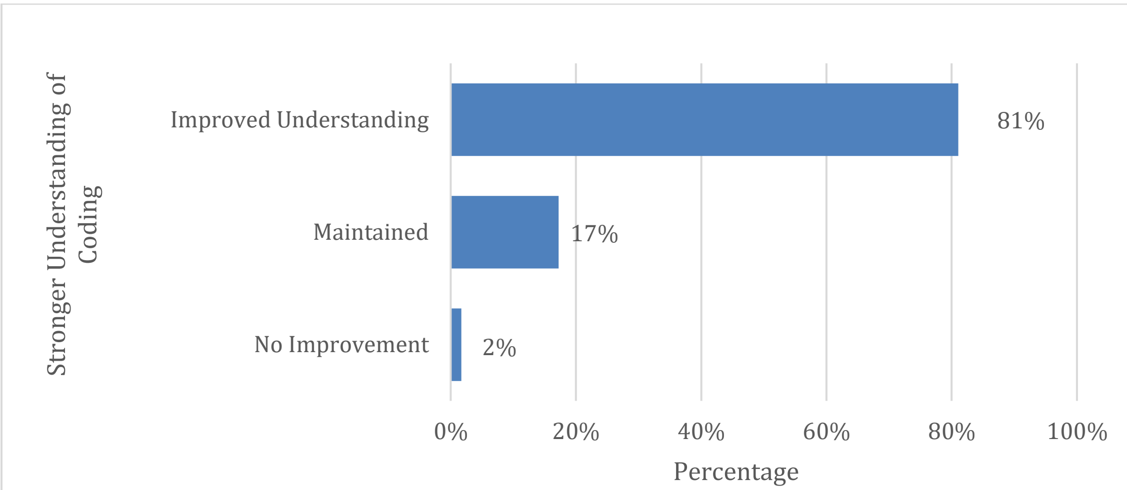


Question 2 asked the students if they felt they had a stronger understanding of coding after completing the program. The survey results demonstrated a positive impact on students' coding skills. A large majority (81%) reported feeling more comfortable and knowledgeable about coding after completing the program. Only a small percentage (2%) saw no improvement, while

17% indicated that their understanding remained about the same. Figure 4 illustrates these results, with only reported responses shown in the figure.

Figure 4

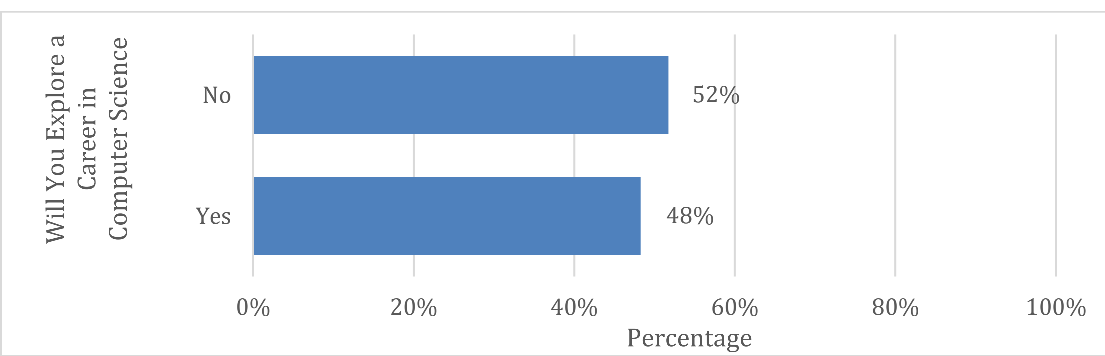
Stronger Understanding of Coding – STEM MiniDomes



The third and final question asked the students if they would explore a career in computer science. Nearly half of the respondents (48%) expressed interest in exploring a career in this field, suggesting that the program was successful in sparking their curiosity and enthusiasm for technology. This is especially true when noting that only 11% of students study computer science when they graduate from similar programs [12]. The program showed promise in inspiring students to consider computer science careers. Figure 5 illustrates these results, with only reported responses shown in the figure.

Figure 5

Will You Explore a Career in Computer Science – STEM MiniDomes



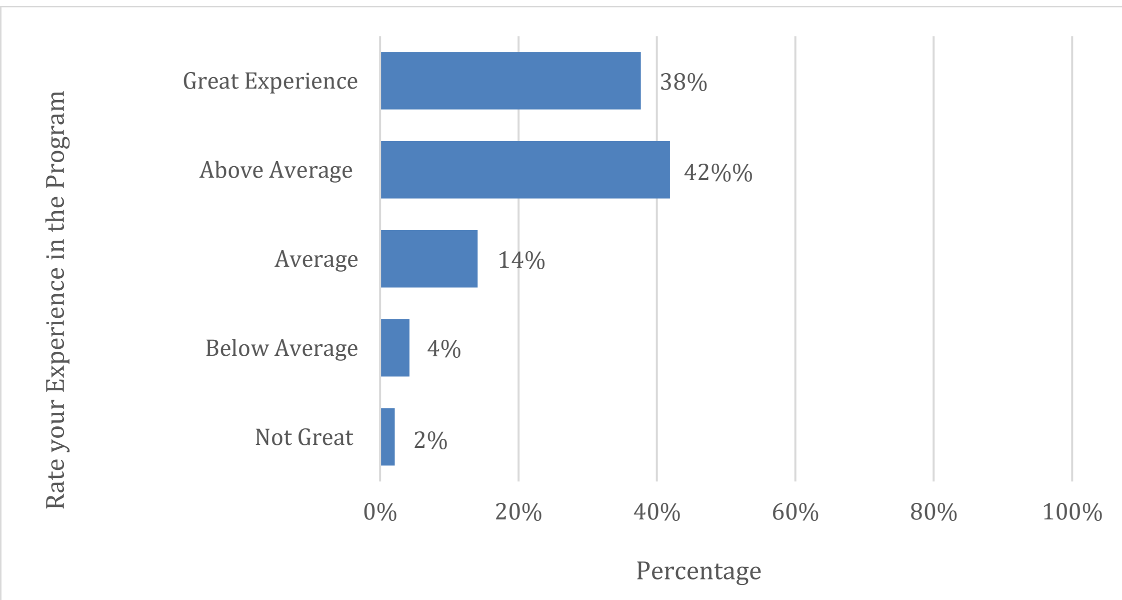
Ohio Code Scholar Year 2: Robot Wars project outcomes

In its second year, the Code Scholar program expanded its reach to more students. Four hundred students from 9 schools, guided by 13 teachers, participated in the Robot Wars project. Together, they built 300 robots over the course of 19 lessons. The participating schools for year two saw a 100% retention rate from the previous year's program, in addition to six new schools. The growth in the school participation is a continuation of where the project participation was rooted in to begin the Ohio Code Scholar Program, building connections. Some of the new schools had attended the year one celebration as part of special invitation to the program, other schools jointed because they talked to the participating schools who mentioned the project-based learning activities and the additional support that was provided. Similar to the previous year, the program involved professors, staff and college students from Southern State Community College. In year 2 of the program, 284 students completed the end of year survey. The survey results for Year 2 mirrored the positive feedback from Year 1.

Question 1 asked the students to rate their experience in the program. While the percentage of students rating the program as a "great experience" decreased to 38%, the students rated the year 2 project well above average (at 80%) when combining the two top categories. Only 6% of students expressed dissatisfaction, when combining the bottom two categories, indicating continued high satisfaction levels. Figure 6 illustrates these results, with only reported responses shown in the figure.

Figure 6

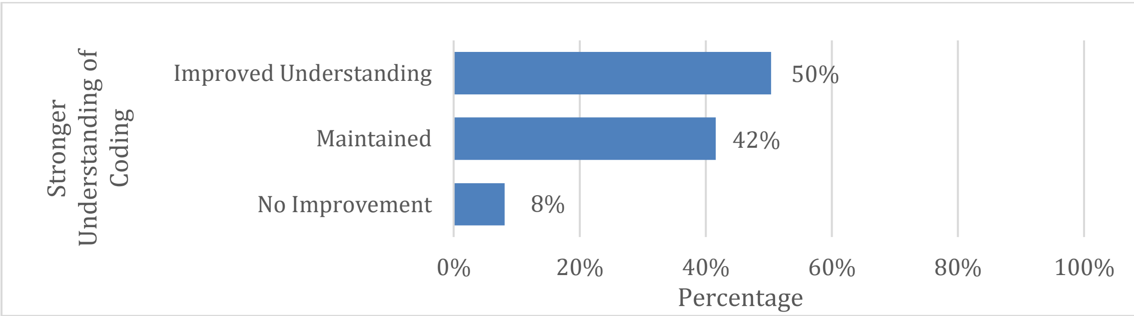
Rate your Experience in the Program – Robot Wars



Similar to year one, students were asked if they felt they had a stronger understanding of coding after completing the Robot Wars program. The program again demonstrated positive results. Many students (50%) reported feeling more comfortable and knowledgeable about coding after completing Robot Wars. However, a larger percentage (42%) indicated that their understanding remained the same, suggesting that the program's effectiveness in improving coding skills may have varied more among students in Year 2. Figure 7 illustrates these results.

Figure 7

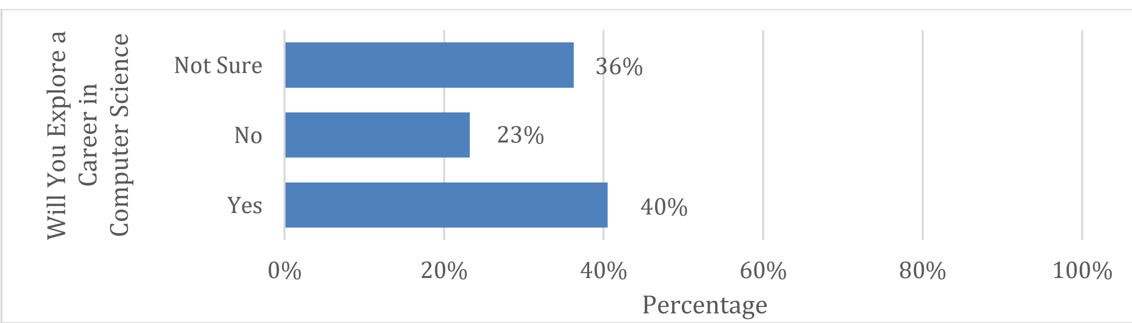
Stronger Understanding of Coding – Robot Wars



Finally, the third question asked around whether students would explore a career in computer science. The program's ability to inspire students to consider computer science careers remained strong. 40% of respondents expressed interest in exploring a career in the field, demonstrating the program's continued success in sparking students' enthusiasm for technology. A new response was included in this year, allowing students to select if they were not sure. Figure 8 illustrates these results, with only reported responses shown in the figure.

Figure 8

Will You Explore a Career in Computer Science – Robot Wars



OSU/COSI Year 2: STEM MiniDome project outcomes

In addition to the Robot Wars project, the Code Scholar program in Year 2 expanded its footprint by engaging with THE Ohio State University in offering the STEM MiniDome project. During Year 2, the MiniDome project involved 80 students by partnering with a school local to THE Ohio State University, where students successfully built 80 domes throughout 22 lessons.

The Year 2 MiniDome project, while conducted on a smaller scale than the Robot Wars project, copied the year 1 project and provided students with similar opportunities to learn coding skills and explore the possibilities of technology. For the college students, the opportunity was provided through a robotics outreach club and advertised in an introductory computer science course. Ten students agreed to participate in the MiniDomes building activity and six agreed to mentor K-12 students in their year-long build processes. Students met once a week and went through mentorship training for the engagement. While specific survey data for this project was not available, positive outcomes were observed in the MiniDome project at a local school. Sample testimonials from the THE Ohio State University students that worked at local school include:

"There is nothing more special than helping a kid configure and program his robot to perform the initial task of lighting up an LED and seeing their face light up even brighter with joy as they know their efforts and work created a real robot! Being a piece of the puzzle with many moving parts and collaborating with organizations to deliver quality STEAM education and exposure programs to the youth really let me know that I can help inspire future generations to make big changes in a big world. I loved working with such bright young minds to accomplish large tasks, and I look forward to participating in similar programs in the future" (K. Paul, personal communication, Sept. 1, 2024).

"I never saw myself becoming an educator. When the opportunity to work in Reynoldsburg came up, I thought it would be a fun experience, but I did not expect much more. However, after working with the students weekly for over three months, it evolved into one of the most educational and fulfilling experiences I have had at THE Ohio State University " (G. Sheppard, personal communication, Sept. 14, 2024).

"Professionally speaking, I had the chance to improve my communication skills as I had to explain complex subjects to children, and I would not have traded that opportunity for anything at that time" (A. Chakraborty, personal communication, Sept. 6, 2024).

Based on our preliminary findings, and consistency found when translating the programming to different school districts and universities, we expect that the curriculum developed and practices learned are transferable to other K-12/University engineering education partnerships. The primary challenge to enable that widely is due to funding limitations at the K-12/University. The projects were not costly averaging $75 per student, but we anticipate this to be a hurdle. Another challenge is finding university faculty that are passionate about this type of K-12 interaction, which we resolved by primarily recruiting teaching and engineering education faculty.

Conclusion

It is critical to the growth of a college and the community it supports to foster relationships with K-12 school districts. This support fosters a pipeline of future problem solvers and innovators. Collaborations, such as the ones discussed in this evaluation paper, helps to expose K-12 students to advanced technologies, real-world applications, and learning methods at a younger age. This early exposure helps younger students develop creativity, analytical skills, and critical thinking, all vital skills for jobs in STEM careers [15].

Beyond strengthening the skills of K-12 students and teachers, initiative such as this strengthens the broader community. When a college invests in the success of its local K-12 schools, it builds a well-educated workforce that can meet local needs [11]. This increase in community building helps build student innovation and a learning culture.

Having college students work in the K-12 classroom also provides more than just expertise to the students and teachers. It also helps to strengthen the skills of college students in the classroom [16]. For example, based on testimonies, we even found that some college students enjoyed the process so much that they considered becoming K-12 teachers, something they had never considered. This reinforcement of the impact of engineering can be of benefit to college students, especially as it addresses the common misconceptions about engineering work that many pre-engineering students maintain.

In conclusion, this study finds that experiential learning can have a powerful impact on STEM education for both K-12 schools and colleges. Using hands-on robotics projects that are fun and engaging for K-12 students and providing meaningful content through a specialized curriculum help the students see the impact engineering can have on their lives. Using fun robotics projects that are either developed by the students or tied to some pop culture reference like Star Wars can provide a hook to the engagement element of the projects. As stated in a recent TED Talk, "It can be a tricky way to educate students" [13]. It should be noted that this study did not collect gender-specific or broader demographic information. Future research could explore whether the Star Wars hook is effective across different genders and demographics to determine its broader applicability. Supporting the K-12 schools and teachers with college students and professors helps to address the lack of specialized educators in engineering fields in K-12 schools. Collaboration does more than build skills in K-12 teachers and students; the college students who participate also develop skills in communication and mentoring.

The case studies from the two projects demonstrate significant success. In Year 1, 48% of participating students expressed interest in pursuing computer science careers—an impressive contrast to the national average of 11%. In Year 2, even as the program scaled to reach more students, 41% reported a desire to explore careers in the field, indicating sustained enthusiasm for STEM education. Furthermore, the students' skills in coding and problem-solving improved notably, with the majority feeling more confident in their abilities after completing the lessons. The celebration event at the end of the year-long program further engages the projects. It provides a goal for everyone to work toward, as prizes, competitions, and fun engagement activities await the students. These activities strengthen the relationships of all stakeholders in the program. Ultimately, these initiatives represent a successful model of educational partnerships that can inspire future efforts to enhance STEM learning and build well-educated, creative, and resilient communities. These programs create a stronger community of future innovators!

Acknowledgment

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