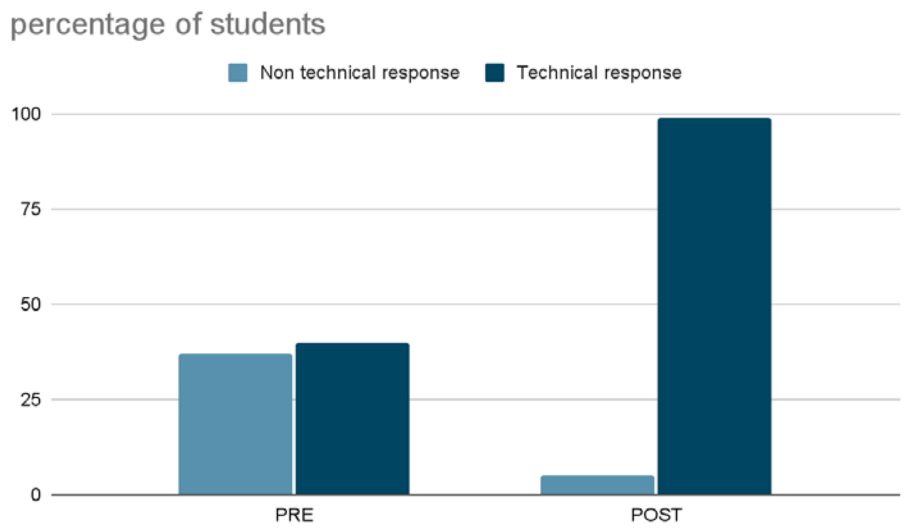

Fig. 2. Percent of students giving non-technical and technical responses on open-ended knowledge questions: “What parts did Daniel use to make the blades spin?”

2) Improved Confidence

Given the self-reported and demonstrated learning improvements in technology and robotics, it is not unexpected that students' trust in technology increased as well. A McNemar's Test revealed a significant rise in the proportion of students who disagreed with the statement on the post-survey on the Confidence subscale Likert-type item, "I am not competent at constructing robots," 2 (1) = 5.7, n = 50, p =.024. That is, the number of pupils who spoke up for their own ability in building robots grew. This interpretation is backed by data from a previous extracurricular robotics pilot, which likewise discovered an increase in student trust in robots [4], as well as short answer replies mentioned below.Students answering the question, “How did this experience change how you think about technology?”, mentioned that they felt more confidence in their technology skills after the project. Some students noted increased confidence in programming, for example, "I've always assumed that technology was just too sophisticated for me to ever comprehend programming and how it works." "I now know that if I want to, I can learn fundamental programming abilities." "I always assumed technology was for dudes," stated another girl (7th grade female, technology education). I now see that robotics is not just for males; I, too, can study it" (10th grade female, technology education). Other students gained confidence while working with the hardware, developing the structures of their robots, and presenting on their final projects. "I believe I became a lot better at understanding how to wire things up to the motors, and it taught me not to give up," (8th grade female, academic language arts).

Aside from increased confidence in certain technical abilities, the experience led to a transformation in identity with regard to technology for some pupils. One student, for example, stated that "using the robotic aspects helped me feel more connected and competent." It made technology feel more approachable rather than something only extremely brilliant people or nerds do" (8th grade female, accelerated language arts). This discovery of enhanced technological confidence lends credence to the second hypothesis, "The robotics camp promotes student enthusiasm and confidence to engage with technology."

TABLE II. WHAT WAS THE BEST THING THAT YOU LEARNED DURING THE PROJECT? RESPONSE SUMMARY

What was the best thing that you learned during the project?	**Percent of Students** N = 50
Technical Learning	70.8%
Teamwork (positive indication)	65.3%
Multidisciplinary Integration	40.5%
Confidence and boldness to speak up	70.89%

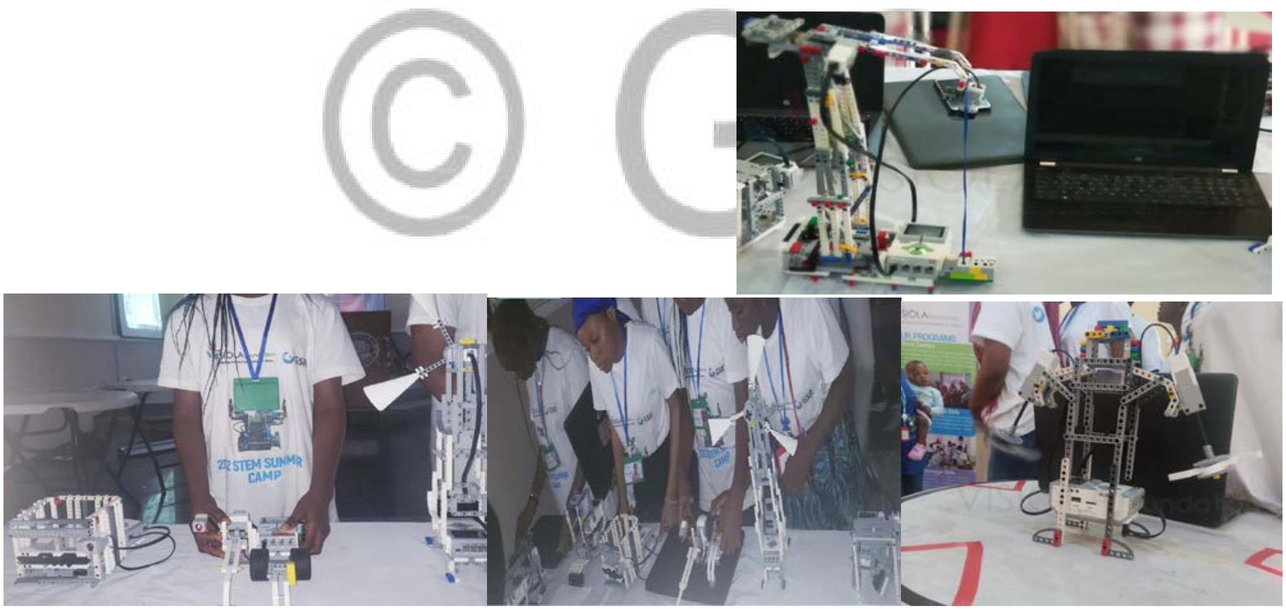

Fig. 3 Some of the final projects done by the students.

3) Breaking technology stereotypes

One intriguing feature of the robotics camp experience was how it challenged kids' preconceived notions about technology. When asked, "How did this experience impact how you think about technology?" 40.8% of students (N=50) said it was more difficult than they expected. One student, for example, stated that "this experience transformed how I think about technology since I assumed all technology was easy for me." After doing this job, I realized it was actually challenging." (9th grade girl, language arts accelerated). This was the question's highestscoring sub-code. We do not believe this merely means that pupils found the project too difficult. Instead, we feel that students developed a more realistic awareness of the difficulties that come with complicated, real-world engineering design issues. Examining all children in our selected group (7th and 8th grade on their first robotics experience) with post-survey findings, some (17.8%, N=50) stated that technology was more difficult than they had anticipated. 87.0% of these students said they enjoyed the project, while 13.0% said they didn't. To put it another way, just because students found technology more difficult than they expected does not mean they did not like the assignment. In contrast, 40.5% of students (N=50) indicated that technology was less difficult than they expected.

"After this experience, I believed that technology wasn't as complex as I imagined it would be and that it wasn't only a wonderful learning opportunity but also a fun endeavor," one student stated. 7th grade girl, advanced language arts. Because many students responded to the question, "How did this experience change how you think about technology?" With statements about how technology was either harder or easier than they had expected, it appears that first-hand experience assisted students in developing a more realistic metric of the complexity of technology development. This actual assessment of difficulty adds to the evidence that "the robotics summer camp promotes student foundation in technical knowledge and abilities.".

TABLE III. DID YOU ENJOY DOING THIS PROJECT? WHY OR WHY NOT? RESPONSE SUMMARY

Did you enjoy doing this project? **Why or why not?**	**Percent of Students** ***N=50***
Yes - Technical Learning	40.5%
Yes - Enjoyed Technology	45.4%
Yes - Novelty of Experience	23%
Yes - Teamwork (positive indication)	65.4%
Yes – Fun Experience	56.4%
Yes - Enjoyed Building	25%
Yes - Vague Learning Gain	45.5%
Yes - Creative	23.6%
No - Teamwork (negative indication)	15.6%

Students also stated that they had a greater appreciation for technology. 17.1% of students (N=50) said that it boosted their respect for technology in response to the question "How did this experience alter how you think about technology?" Increased appreciation responses might include admiration for the intricacy of technology, knowledge of technology's applicability in everyday life, or reporting a new viewpoint on technology. One student, for example, stated, "This experience helps me appreciate folks who perform computer programming for a job." (7th grade girl, advanced language arts), and "This experience altered my perspective on technology since I used to believe that technology simply consisted of mobile phones and devices like that, but now I realize that there is more to technology than meets the eye." (10th grade female, accelerated language arts).

Students expressed a greater appreciation for technology in their replies to other questions as well, but in lower proportions: "Should other students have this experience?", 40.3% (N=50); and "What was the best thing you learnt throughout the project?" 50.2% (N=50). The stated rise in appreciation for technology reflects student views on the importance of technology in their lives and the globe. Because value is a motivating component, these data support the hypothesis about motivation and confidence.

Students reported learning about innovative uses of technology, which is not surprising considering the creative and multidisciplinary character of the robotics summer camp projects. In response to the question "What was the best thing you learned throughout the project?" 6.5% of students (N=50) highlighted the interdisciplinary nature of technology. "Energy transformation may be really tough to grasp," one student said, "but utilizing robotics and developing a visual perspective of it can help you understand it more." Female, eighth grade, advanced language arts. "Did you like working on this project?" 40.6% of students (N=50) said the assignment was enjoyable because it was innovative. For instance, a student stated, "Yes, I enjoy how individuals can be creative with their thoughts since there are so many possibilities to choose from." (8th grade female, accelerated language arts).

This acknowledgement of technology as a creative medium is consistent with both the definition of technology as the creative use of technology and the purpose of the robotics summer camp program, which is to provide a robotics intervention for girls that focuses on creativity and self-expression.

TABLE IV. HOW DID THIS EXPERIENCE CHANGE HOW YOU THINK ABOUT TECHNOLOGY? RESPONSE SUMMARY

How did this experience change how you think about technology?	**Percent of Students** ***N=129***
More challenging than I thought	17.8%
Gained appreciation for technology	17.1%
Technical Learning	13.2%
Less challenging than I thought	11.6%
No change reported	10.5%
Increased enjoyment of technology	15.6%
Increased perseverance	20.5%
Increased interest in technology	30.5%

Increased confidence with technology	40.5%
Found technology to be fun	45%

Finally, students claimed that the robotics summer camp influenced their thoughts on technical jobs or that the learning is relevant to their futures. When asked if "other pupils should have this experience?" Because it will benefit their future or job, 82.5% of students (N=50) replied yes. "I think other students should have this experience because it might boost your potential to one day go to college and maybe possibly have a profession in technology," one student remarked. (Female, 10th grade, advanced language arts). This was the second most popular response category for this question, behind only yes because it was entertaining (33.1%, N=50). This suggests that students respect the importance that technology may play in their classmates' future lives and jobs and believe that the robotics summer camp contributes positively to this role.

In summary, student responses indicate that students' understanding of the complexities of engineering design and technical projects became more grounded in reality, students came to appreciate technology in the larger world around them, students came to see that technology could have creative applications, and students considered the benefits of what they had learned from the project for their future lives.

B. Complementary Non-Technical Skills

1) Teamwork

We noticed indications of students gaining non-technical abilities in addition to the core aim of enhancing technology skills, knowledge, and attitudes that comprise student technological fluency. Teamwork and collaboration were two of the most prevalent non-technical abilities cited by students in their short answer replies. When asked, "What was the nicest thing you learnt throughout the project?" The second most popular code (22.3% of students) was only topped by learning about technology (56.8%). (N=50). One student, for example, stated that they learnt "not to criticize anyone for their errors because [you] will make at least one and you do not want to be blamed" (10th grade female, accelerated language arts).

TABLE V. SHOULD OTHER STUDENTS HAVE THIS EXPERIENCE? WHY OR WHY NOT? RESPONSE SUMMARY

Should other students have this experience? Why or why not?	**Percent of Students** ***N=50***
Yes – Fun Experience	33.1%
Yes – Novelty of Experience	18.5%

Yes – Teamwork (positive indication)	17.7%
Yes - Vague Learning Gain	15.4%
Yes - Technical Learning	10.0%
Yes – Career/Future Benefits	6.2%

Teamwork appeared in the responses to other questions as well. For “Did you enjoy doing this project?”, 13% of students (N=50) reported that they enjoyed the project because they enjoyed the teamwork. When asked “Should other students have this experience?”10.0% of students (N=50) said yes because they would practice teamwork. For example, one student responded, "yes because it alters your perspective on how you can accomplish tasks and collaborate with other students." (10th grade girl, accelerated language arts) and "Yes, I believe a lot of people my age would appreciate this, because it brings together both tech aware individuals and those who can work effectively with their hands." Female, 10th grade, academic language arts This tendency is especially striking because neither the Attitudes nor Knowledge surveys expressly discuss collaboration. Following the summer robotics camp, we found a reduction in the proportion of students who agreed with the statement "It's vital to me to know more about technology than most others."A McNemar’s Test indicated this was a significant decrease in the proportion of students, $\chi2$ (1) = 6.7, n = 50, p = .014. At first glance, this decline in the perceived value of technological expertise appears depressing; nevertheless, we believe that the collaborative features of the summer camp project shift the relative value students assign to their knowledge and abilities. Some student responses to open-ended questions support this interpretation, such as "the best thing I learned in this projected [project] was that everybody did something to help the group so it would be teamwork" (10th female, academic language arts) and "that you need to make sure everyone is working and following along to the best of their ability so you get it done quickly." (Female, 10th grade, advanced language arts).

Student remarks like the ones above strongly reinforce the premise that students not only learned the importance of communication and collaboration, but also grew to respect their colleagues' contributions to the successful completion of a technical project of this magnitude. Teamwork was such an important part of the student experience. We often hear from children who had bad collaboration experiences at summer camp. Negative collaboration was the most common negative response code for "Did you enjoy doing this project?" (4.6% of students, N=50). While the majority of students who mentioned cooperation thought it fun or productive, some reported unfavorable teamwork experiences. Anecdotal evidence from instructors suggests that cooperation is a particularly difficult topic for middle school pupils, therefore witnessing both good and negative reactions to teamwork is common.

The importance of cooperation in short response questions can be attributed to the important role that teamwork plays in summer camp projects. These summer camp projects were so large that no single student could accomplish them on their own. Furthermore, the intricate, interrelated structure of engineering design projects necessitates tight collaboration among students rather than merely working in parallel. In summary, the robotics camp requires children to work together.

2) Other Skills

While collaboration was the most often mentioned non-technical talent by students, numerous other abilities were mentioned in the open-ended question replies. The most prominent of these was perseverance, with 5.4% of students (N=50) indicating increased perseverance with technology in response to the question "How did this experience impact how you think about technology?" Responses saying that the project or technology was tough but rewarding or beneficial in the end, for example, ".... The usage of the different robot parts was challenging but highly gratifying in the end, but not as challenging as predicted," were categorized into this category. Male, eighth grade, advanced language arts.

Perseverance emerged in lesser doses in answer to other questions, such as "What was the best thing you learnt during the project?" "Should other students have this experience?" 2.9% (N=50). 2.3% (N=50); 0.8% (N=50) for "Did you like working on this project?" A few pupils mentioned time management and problem solving abilities. In answer to the question, "What was the most important thing you learned during the project?" Time management was reported by 2.9% of students (N=50). When asked if other kids should have this experience, one student mentioned problem solving skills, stating, "Yes, it helps with collaboration and problem solving skills." (9th grade girl, language arts accelerated). Because the hypotheses, professional development, and assessment techniques did not explicitly target these abilities and dispositions, the findings imply an intriguing relationship for future work.

V. FUTURE DIRECTIONS

In the future, we plan to continue to:

1) build on the above-mentioned outcomes, as not all outcomes could be provided within the scope of this research;

2) enhance the robotics camp system; and

3) investigate new areas of assessment. We intend to build on our results about the development of teamwork and other non-technical abilities by creating professional development and curricular resources to assist robotics camp teachers in maximizing these complementing advantages. We will also work to establish more detailed items for quantifying these non-technical achievements.

We are also interested in developing evaluations relating to the robotics camp's interdisciplinary character and curricular integration to assist analyze the influence of the robotics camp on student learning of the core discipline, such as poetry. While we have analyzed data from the whole population of robotics camp students, we would gain more information by comparing subpopulations. To answer our program's aim and premise of "engaging a broad demographic of participants," for example, it will be necessary to analyze the knowledge and attitudes results from the experience by different genders and students with varied experience levels. It will also be interesting to do additional study of the variations in results between different student grade levels in order to assist instructors in selecting learning objectives that may be attained with this and comparable projects in their specific courses. Longitudinal examination of kids enrolled in various robotics camp courses offers another intriguing path for future research.

VI. CONCLUSIONS

The outcomes of the middle school creative robotics project, as well as the robotics camp, were presented here. The purpose of the robotics camp program was to improve middle school pupils' technical proficiency. Students' self-reported learning and pleasure of the creative parts of technology as a result of their participation in the robotics camp provided evidence for this purpose.

Our hypothesis for evaluating the robotics camp program were as follows:

1. The robotics camp improves students' technical knowledge and skills.

2. The robotics camp boosts students' motivation and confidence in using technology.

3. The robotics camp attracts a diverse group of participants, both male and female, with varying levels of technology experience. Student self-reported technical learning, significant improvements in technology component identification, significant increases in understanding of systems engineering concepts, and short answer responses demonstrating the grounding of technology concepts through first-hand experience all supported the first hypothesis.

The second hypothesis was validated by self-reported confidence gains, a rise in students disagreeing with the statement "I am not excellent at constructing robots," and self-reported increases in student appreciation of real-world uses of technology.

The third hypothesis is currently being assessed and, as previously stated, will be the topic of future research. We also noticed high self-reported effects linked to cooperation outside of the initial predictions, which warrants additional specific study and augmentation through future program development.

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