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Applied STEM Summer Institute at East Tennessee State University: Recruitment, Engagement and Pathways to Student Success

Dr. Mohammad Moin Uddin P.E., East Tennessee State University

Dr. Mohammad Moin Uddin is a professor in the Department of Engineering, Engineering Technology, and Surveying at East Tennessee State University.

Dr. Keith V. Johnson, East Tennessee State University

Dr. Johnson is chair of the Department of Engineering Technology, Surveying and Digital Media at East Tennessee State University. He has been active with the American Society of Engineering Education for over 20 years. During that time, he have served in

Dr. Evelyn Roach, East Tennessee State University

Dr. Roach is the director of the Curriculum Innovation Center and Program Coordinator for the Applied STEM Summer Institute.

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Abstract

As the global economy becomes increasingly reliant on technology and innovation, the demand for skilled STEM professionals has never been greater. Recognizing this critical need, East Tennessee State University (ETSU) launched the Applied STEM Summer Institute in the summer of 2024, a groundbreaking initiative designed to inspire the next generation of STEM leaders. This three-week program provides high school students with hands-on experience in various STEM disciplines, primarily focusing on engineering, computing, and digital media. In the first week of the institute, students were introduced to the fundamentals of computational thinking, logical reasoning, and problem-solving using tools like Scratch. The second week, Engineering Week, featured a diverse range of activities including 3D model building, drones, 3D printing, smart home technology, electronics, bioengineering, and robotics. Each day was designed to expose students to different aspects of engineering, allowing them to explore potential areas of interest. The third week of the program immersed students in the world of digital media. Students learned about 2D and 3D computer graphics, using tools like Photoshop and Illustrator for 2D design and advanced software for 3D modeling. The week culminated in a capstone project where students applied their newfound skills. A Pre- and post-survey was administered during the Engineering Week and data analysis reveals that the summer institute not only equips students with valuable skills but also inspires them to pursue college and career paths in STEM fields.

Introduction

STEM summer camps have become increasingly popular as they provide engaging, hands-on experiences that foster interest in science, technology, engineering, and mathematics among young learners [1], [2], [3]. These camps typically offer a variety of activities, including robotics, coding, and environmental science, designed to stimulate curiosity and creativity. For instance, programs like the TryEngineering Summer Institute allow participants to explore different engineering fields through interactive projects and tours of engineering facilities [4]. Such experiences not only enhance students' understanding of STEM concepts but also encourage teamwork and problem-solving skills, which are essential in today's job market [5].

The curriculum of STEM summer camps is often aligned with educational standards and is tailored to meet the diverse needs of participants. Many camps focus on project-based learning, where campers engage in hands-on activities that promote critical thinking and innovation [6]. Additionally, camps like those at UW-Green Bay provide opportunities for campers to design their own video games or create robotic systems, making learning both fun and relevant [7] . This approach not only helps in reinforcing academic concepts but also prepares students for future careers in STEM fields, which are projected to grow significantly in the coming years.

Moreover, STEM summer camps play a crucial role in addressing the gender and diversity gaps in STEM education. Programs are increasingly designed to be inclusive, encouraging participation from underrepresented groups. Initiatives like STREAMWORKS aim to ignite curiosity and innovation among all students, regardless of their background [8]. By fostering an inclusive environment, these camps help cultivate a new generation of innovators and problem solvers who are equipped to tackle the challenges of the future [9], [10], [11]. As such, STEM summer camps not only contribute to individual growth but also to the broader goal of enhancing diversity in STEM professions.

As the global economy increasingly relies on technology and innovation, the demand for skilled professionals in Science, Technology, Engineering, and Mathematics (STEM) has never been higher. Recognizing this critical need, ETSU launched the Applied STEM Summer Institute, a groundbreaking initiative aimed at inspiring the next generation of STEM leaders. This three-week program is designed to provide high school students with hands-on experience in various STEM disciplines, helping them explore potential career paths and develop the skills needed to succeed in these fields.

ETSU Applied STEM Summer Institute

The following sections provide a brief description of the ETSU Applied STEM Summer Institution: its development, activities, student engagement and operations for the first year in 2024.

Building Strong Partnerships

The Applied STEM Summer Institute stands as a testament to the power of collaboration. The success of the program is deeply rooted in the strong partnerships ETSU has cultivated across various departments, organizations, and industry stakeholders. These partnerships not only provided essential resources but also brought a diverse range of expertise to the program, enriching the students' experience.

One of the most significant partnerships was with the Reserve Officers' Training Corps (ROTC). Beyond their contribution of time and mentorship, ROTC provided 200 water bottles and backpacks, ensuring that students were well-equipped for their daily activities. SFC Timothy M. McCravey and Keith Linville, Recruiting Operations Officers, expressed their enthusiasm for continuing their support in future summer programs.

The admissions office also played a crucial role by sponsoring 150 t-shirts, fostering a sense of unity and belonging among participants. The Office of Professional Development contributed by organizing minor on-campus training sessions and managing the program application and attendance list, ensuring smooth operations throughout the program.

ETSU's commitment to academic excellence was reflected in the involvement of several academic departments. The Digital Media department committed to a three-year partnership, providing course content, staff, and even designing the official camp t-shirt. This long-term commitment underscores the department's dedication to promoting digital media as a viable and exciting career path. Similarly, the Computing and Engineering departments contributed by offering faculty to teach various modules and providing departmental t-shirts, further enhancing the students' immersion in the STEM fields. These experiences provided students with a holistic

understanding of STEM, bridging the gap between theoretical knowledge and real-world application.

Financial support was instrumental in making the program accessible and sustainable. Dean of Arts and Sciences contributed $5,000, while Director of the STEM Center donated $500 towards purchasing materials. BrightRidge and the Tennessee Valley Authority (TVA) made a substantial commitment of $100,000 to support the program for three years, ensuring its continuity and expansion.

Strategic Planning and Program Design

The Applied STEM Summer Institute was conceived as a dynamic, hands-on program designed to immerse high school students in STEM disciplines. The initial planning began in Fall 2023, with the goal of creating a program that would not only educate but also inspire students to pursue careers in STEM. The program targets high school students who have shown an interest in STEM majors, providing them with an in-depth look at ETSU's offerings in Mechatronics, Digital Development, Engineering Technology, Digital Media, and Computing.

Initially, the program was designed to span four weeks, with each week dedicated to a specific area of study—computing, digital media, engineering, and a final week focused on project consolidation. However, after careful consideration and feedback, the program was condensed to three weeks to better accommodate students' schedules and maintain a high level of engagement throughout the program.

One of the key aspects of the program design was affordability and accessibility. To ensure that the program was accessible to all students, regardless of their financial background, a nominal fee of $25 was set. In addition, the program provided lunch and snacks, alleviating any concerns about additional costs for families. This approach reflects ETSU's commitment to inclusivity and equity in education.

Recognizing the importance of academic achievement, the program included a unique opportunity for students to earn college credit. The STEM 1050 – Applied STEM Foundation course was developed to complement the summer institute, offering students two college credits upon enrolling at ETSU. This course is designed to deepen students' understanding of STEM through practical applications, data handling, and career exploration. By linking the summer institute to college credit, ETSU not only incentivized participation but also provided students with a head start in their academic journey.

In-Depth Summer Institute Activities

The Applied STEM Summer Institute was structured around three thematic weeks, each focusing on a different STEM discipline: Computing, Engineering, and Digital Media. This approach allowed students to explore a broad range of subjects while gaining hands-on experience in each area.

Week 1: Computing

The first week of the program introduced students to the fundamentals of computational thinking, logical reasoning, and problem-solving. Using tools like Scratch, students learned to decompose complex problems into manageable parts, recognize patterns, and develop algorithms. These skills are foundational to any career in computing and provided students with a strong base for further exploration. In addition to technical skills, students were introduced to the broader field of information systems, learning how organizations use information to achieve

their goals. This included an overview of databases, SQL, and the role of information technology in supporting business processes.

To complement the academic activities, the week included a unique fitness challenge conducted by ROTC. Students participated in the Army Fitness Test, which included events such as the Hand Release Push-Up, Plank, Sprint/Drag/Carry, and Standing Power Throw. This activity not only emphasized the importance of physical fitness but also introduced students to the opportunities available through military education and scholarships.

Week 2: Engineering

The second week focused on various engineering disciplines, offering students a hands-on introduction to the engineering field. Activities ranged from guitar building, electronics to bioengineering and robotics. Each day was designed to expose students to different aspects of engineering, allowing them to explore potential areas of interest.

In addition, students engaged in cutting-edge activities such as site mapping using drones, indoor drone competitions, 3D scanning of historic buildings, and 3D printing. As the culminating project, students worked in teams to assemble an ESP32 Controlled Smart Home IoT Kit. With multiple sensors and actuators, students designed various smart home features such as a password-protected door, window controls, PIR motion sensors, hazardous gas alarms, fan modules, and more. Overall, engineering week introduced students to different engineering areas, skills, and job prospects, showcased technological advancements in engineering, and allowed students to apply their skills in a fun project.

Week 3: Digital Media

The final week of the program immersed students in the world of digital media. Students were introduced to 2D and 3D computer graphics, learning tools like Photoshop and Illustrator for 2D design and advanced software for 3D modeling. The week culminated in a capstone project where students applied their newfound skills to create a model of a place significant to them, blending creativity with technical expertise.

The digital media component of the program was designed to bridge the gap between art and technology, highlighting the interdisciplinary nature of modern STEM careers. By engaging in both 2D and 3D projects, students gained a comprehensive understanding of the digital media landscape and its applications in various industries.

Engagement, Inclusion, and Student Development

One of the most challenging aspects of the Applied STEM Summer Institute was ensuring sustained engagement among students throughout the three-week program. To address this, the program was designed with a strong focus on interactive, hands-on activities that kept students motivated and excited about learning.

Building bonds among students was a key objective. From day one, the program fostered an environment of collaboration and friendship. This was particularly important for students who were homeschooled or came from different educational backgrounds. By the end of the program, many students had formed lasting friendships and felt a sense of inclusion and belonging.

The program also emphasized the importance of free time and social interaction. A longer lunch break was initially included to allow students to relax and socialize, but based on student feedback, the break was shortened in the following weeks to maintain momentum. This

adaptability in the program design ensured that students remained engaged and enthusiastic throughout the three weeks.

Data Collection and Analysis

For the Week 2 Engineering Camp assessment, we developed and administered a survey on the first and last days of the week to serve as pre- and post-assessments. The goal of the survey was to capture students' overall understanding of the engineering profession and analyze various characteristics that might influence their future career decisions following their participation in the summer camp. There were 20 questions in the survey and we had 80% response rate. The remainder of this paper presents the participants' survey responses and summarizes relevant descriptive statistics.

Participants

A total of 25 students attended the Week 2: Engineering Camp. Most of the students who participated in the summer camp were from minority groups (56%). This is encouraging since minority groups are underrepresented in the engineering profession. Among them 19% were African-American, 6% Hispanic, 12% Asian, 13% mixed race and 6% other and the remaining 44% identified as White (Figure 1). Over 60% were nineth and tenth graders and a quarter were female. Most of the campers self-reported that they were from middle income family (Figure 1).

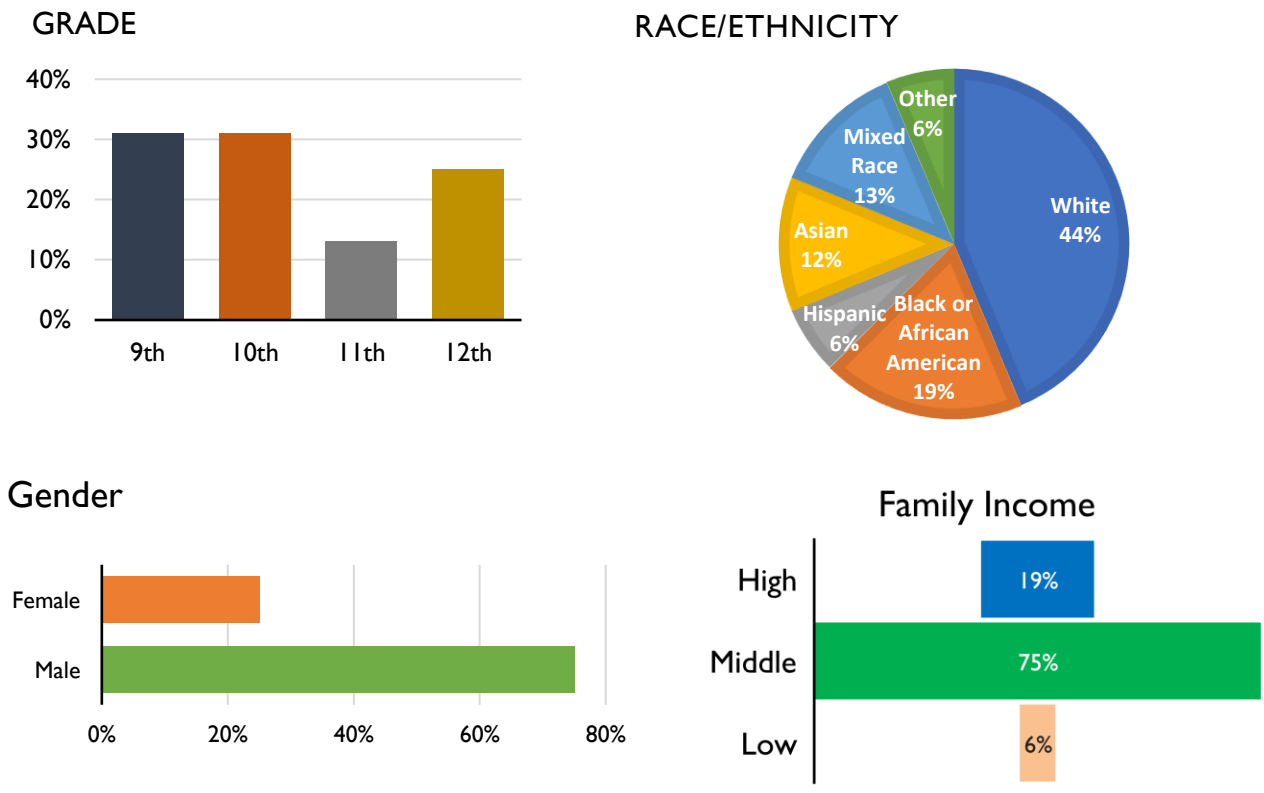

Fig. 1. Camp participants' demographics

Campers Understanding of Engineering Profession

Research consistently demonstrates that a student's knowledge about STEM careers directly impacts their interest in pursuing a STEM occupation [12], [13]. The more informed they are about STEM fields, the more likely they are to consider a career in that area. This increased interest is often attributed to factors such as enhanced self-efficacy and a better understanding of potential career paths within STEM. In response to the question, “What do engineers do?” the pre-camp survey revealed that students had a limited understanding of the engineering profession. Students were given six prominent activities that engineers typically perform, as shown in Figure 2. We expected that students would choose all six activities, but only 56% selected all six. However, in the post-camp survey, all but one student selected all six activities, implying that the camp effectively informed students about the engineering profession. The pre-camp survey suggests that the lack of students entering engineering programs may be due to a lack of understanding of the type of work engineers perform. There are numerous engineering and technology career options available, and it is crucial for the engineering profession and educators to clearly communicate and introduce these professions to K-12 students to increase their interest in engineering.

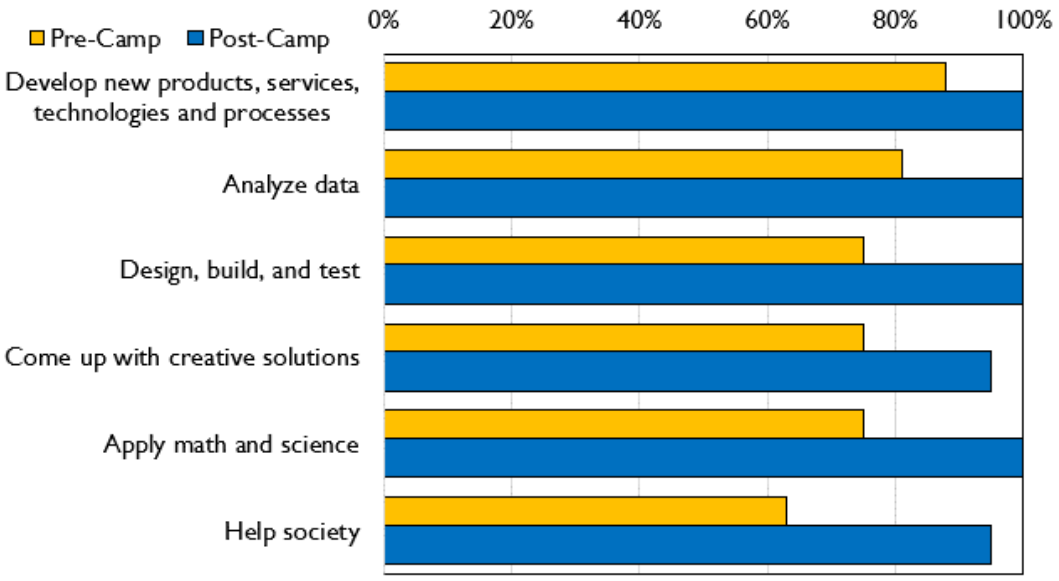

Fig. 2. Pre vs post camp students’ responses to the question “What do you think engineers do?”

Factors Contributing to Campers’ Interest in Studying Engineering

We asked students why they might be interested in engineering (Figure 3). Before the camp, students cited personal interests such as "I like to figure out how things work" and "I like to build stuff," as well as their perceptions of the engineering profession, including "Engineers are well paid" and "I think engineering is fun," as top reasons. After a week of hands-on activities, demonstrations, and interactions with engineering professionals, it seems the camp activities enriched students' understanding of engineering and boosted their confidence in these areas. These findings align with previous studies, such as Long [14], Yilmaz [15], and who found that exposure to hands-on engineering activities and real-world problem-solving tasks during camps

significantly boosts students' interest by providing practical experience and demonstrating the relevance of engineering in everyday life. Interaction with engineering professionals and mentors helps students envision themselves in similar roles, thereby increasing their interest in pursuing engineering careers [16].

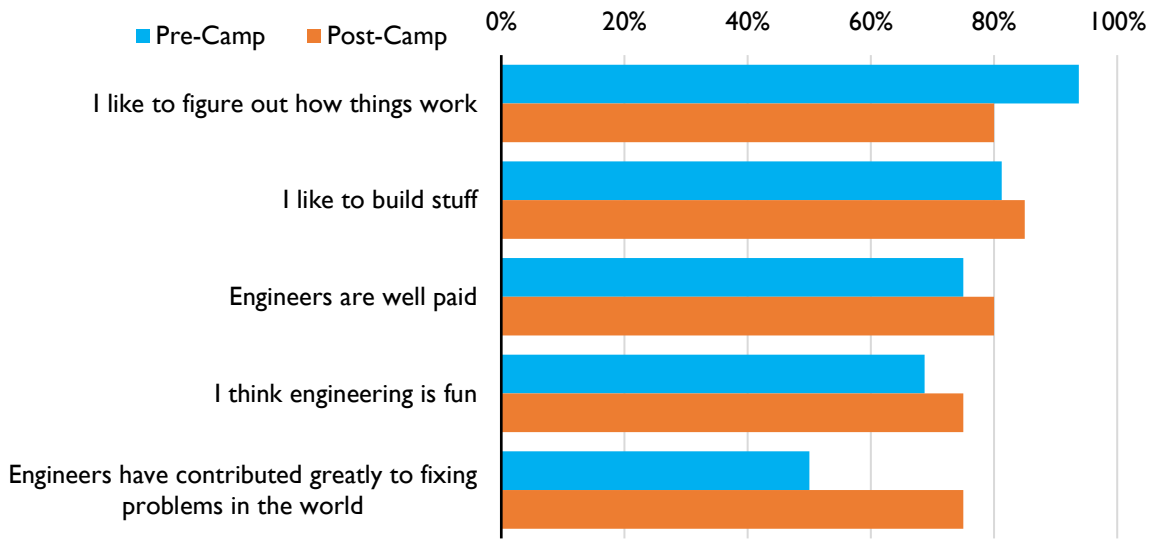

Fig. 3. Pre and post survey changes in factors contributing to campers' interest in studying engineering

Campers Self-Assessment of Skills Needed to be a successful Engineering Professional

Students were asked what skills they think are necessary to be successful in engineering (Figure 4). In the pre-camp survey, most students selected critical thinking, math and science abilities, and leadership as the most important skills. However, in the post-camp survey, communication and teamwork skills, along with math, science, and critical thinking, topped the list. It appears that a week of hands-on activities and group projects helped students realize the importance of teamwork and communication (soft skills) in addition to the technical skills needed to succeed in the engineering profession.

Campers Interest in Attending College

Analysis of student feedback revealed that they enjoyed the camp activities, which provided them with a better understanding of the engineering profession. After the camp, all of the students expressed their interest in attending college (Figure 5). More than 80% of the students mentioned that the camp made them more inclined to study engineering (Figure 6).

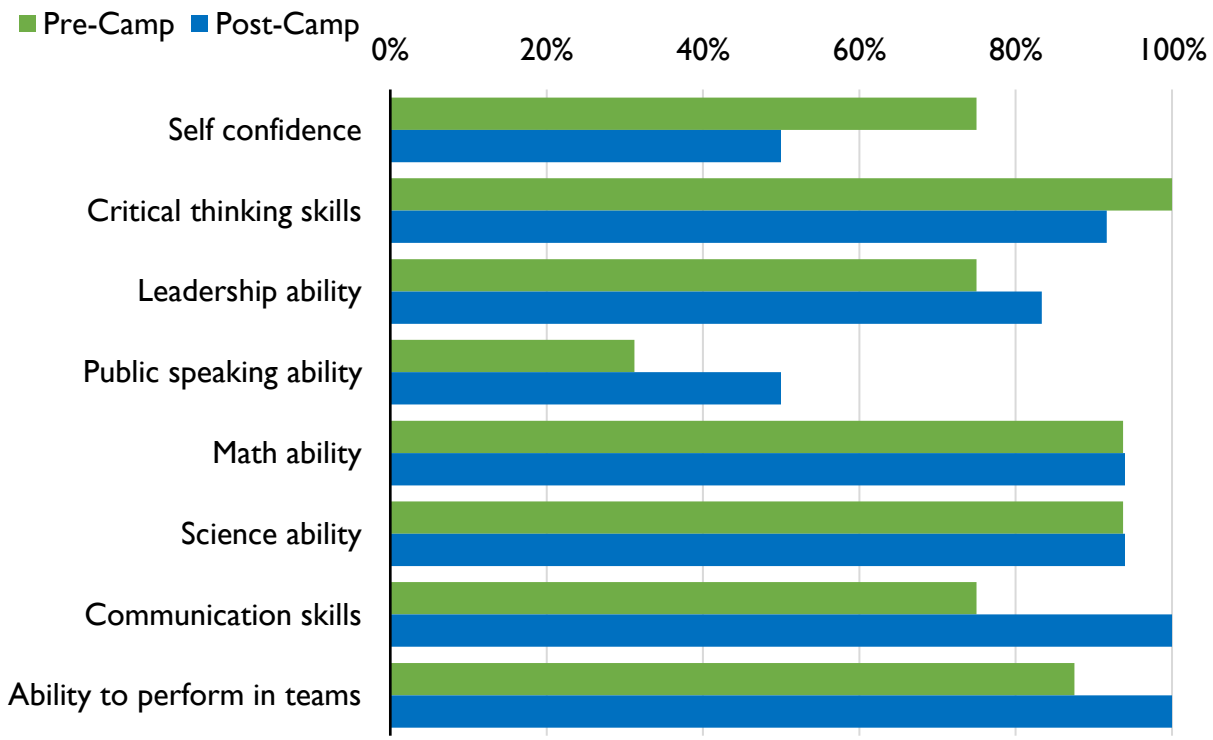

Fig 4. Changes in campers' perceptions of skills needed to be successful in the engineering professional

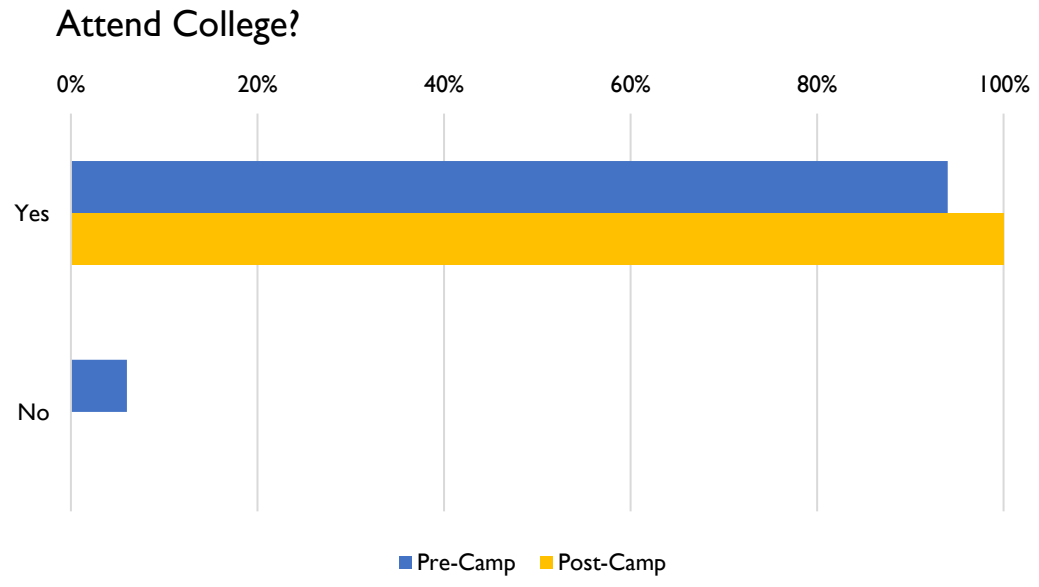

Fig 5. Do you plan to attend college?

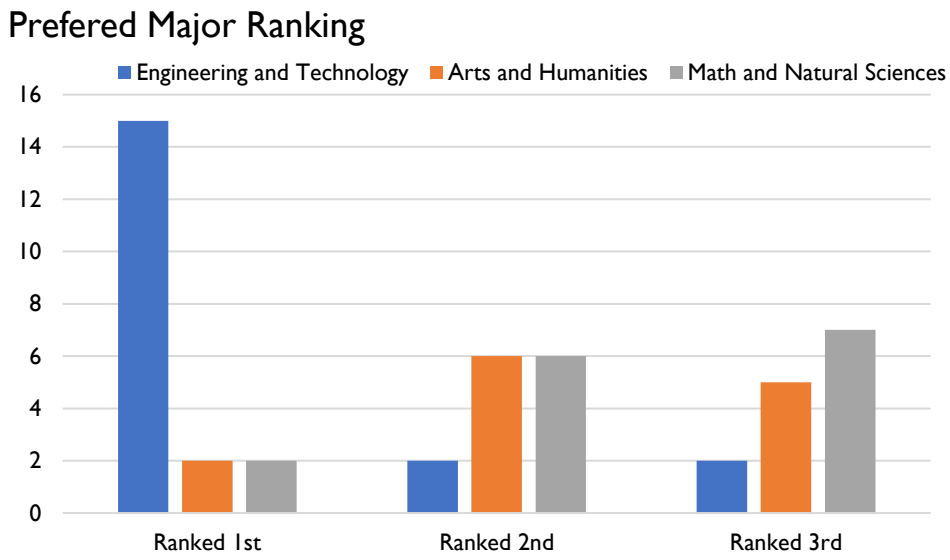

Fig. 6. Campers' rank of preferred STEM major.

Need for Pre-College Student Support

In the survey, students identified several areas where they needed help (Figure 7). Most students reported needing significant assistance with admissions, financial aid, and scholarships. These were followed by career preparation and extracurricular activities they are interested in pursuing in college. A comprehensive support system involving parents, K-12 educators, counselors, and higher education entities is needed to fill these gaps and provide the knowledge, services, and confidence required for more students to pursue engineering.

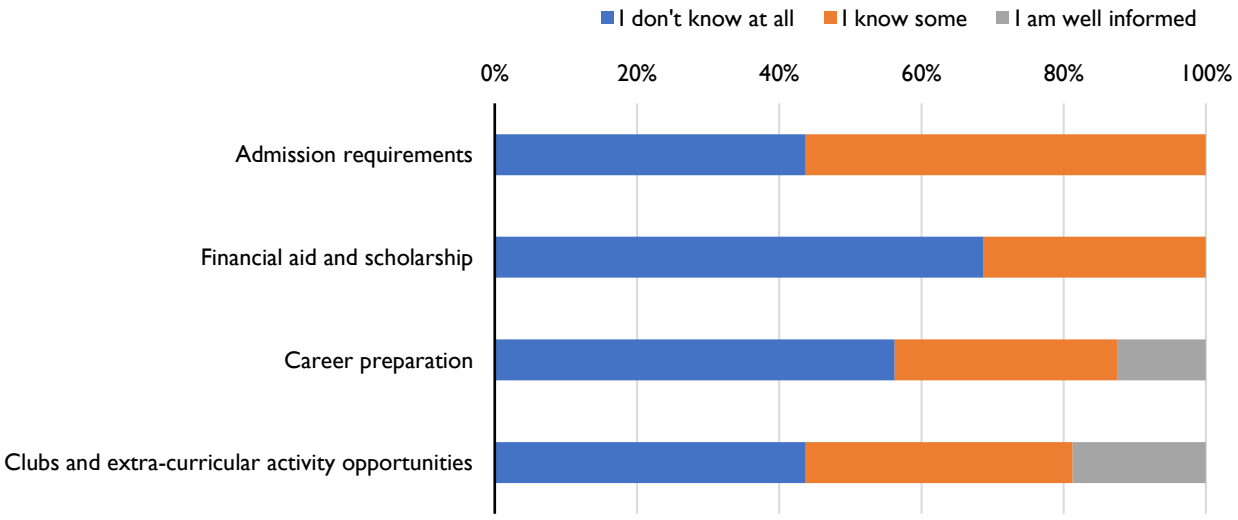

Fig 7. Campers' need for pre-college student support

Conclusion and Future Work

The Applied STEM Summer Institute at ETSU represents a significant step forward in preparing the next generation of STEM professionals. By offering a comprehensive, hands-on exploration of STEM disciplines, the program not only provides students with valuable skills but also inspires them to pursue careers in these critical fields.

The success of the program has laid the foundation for future expansions and improvements. With continued support from partners, faculty, and the broader community, the Applied STEM Summer Institute is poised to grow, offering even more students the opportunity to explore STEM careers and gain a head start on their academic journey.

Looking ahead, ETSU aims to build on this success by expanding the program to include more specialized tracks, incorporating new technologies, and strengthening partnerships with industry leaders. As the program evolves, it will continue to empower students to explore their passions, develop critical skills, and envision a future where they can make a meaningful impact in the world of STEM.

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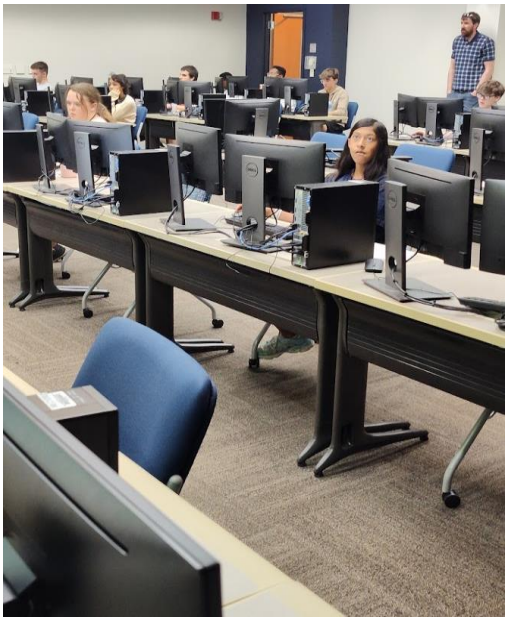
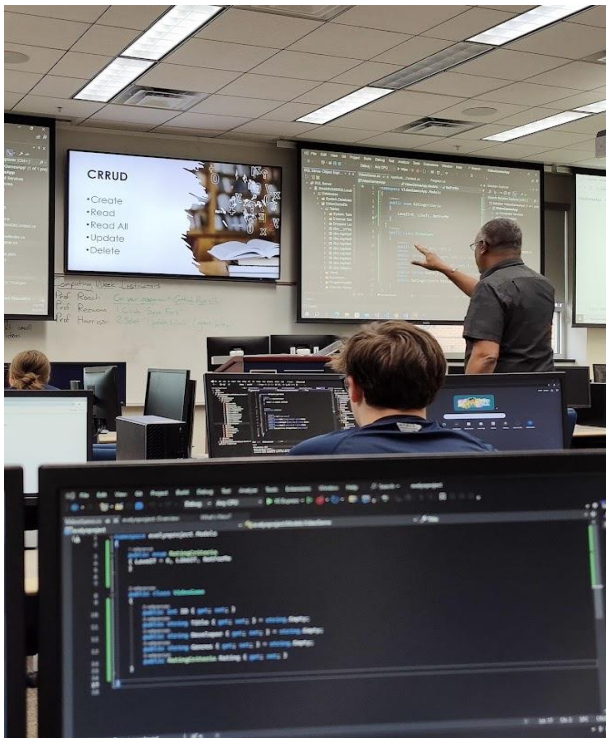
Below are some images of students seeing the evolution of computers and storage devices as well as in class learning.





Week 1 -Army Fitness Test on the quad. ROTC conducted 4 of the events from their fitness test which are the Hand Release Push-Up, Plank, Sprint/Drag/Carry, and Standing Power Throw. This event was a 1 hour long. Its aim is to teach students about fitness and also introduce them to how the military can pay for schooling

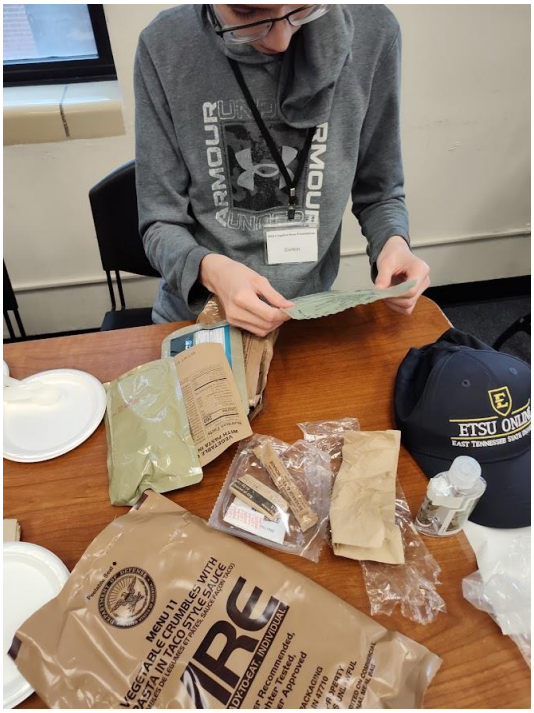
Week 2 -Campus familiarization. Go to admissions to get copies of the campus map. We will split the students into groups and assign them certain buildings or landmarks to find. Once found, they will take a group selfie as their proof. The first team to complete this will win a TBD prize.

Week 3-Chop Challenge with Army MREs. Students will produce basic meals with MREs and plan to split the students in 3 people teams. Whoever produces the best meal will win a TBD prize.

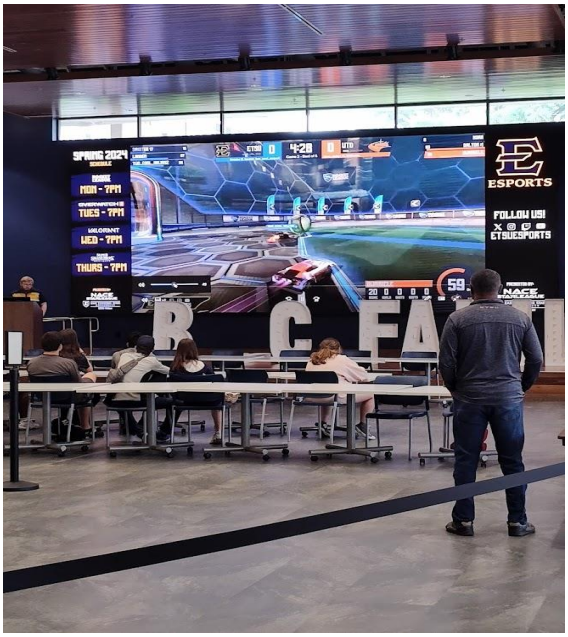
Week 1 ROTC fitness test.

Health and wellness is part of the program and we incorporate activities that allow the students to challenge themselves while also learning how they can get college paid for by joining X ROTC

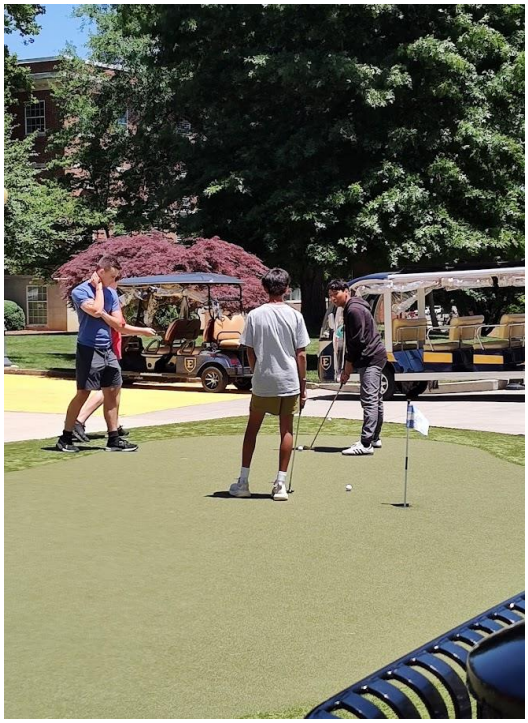
ROTC Cooking challenge using MRE. Students got a lesson on the science behind MRE, the use of MRE and how these can help during times of disasters.

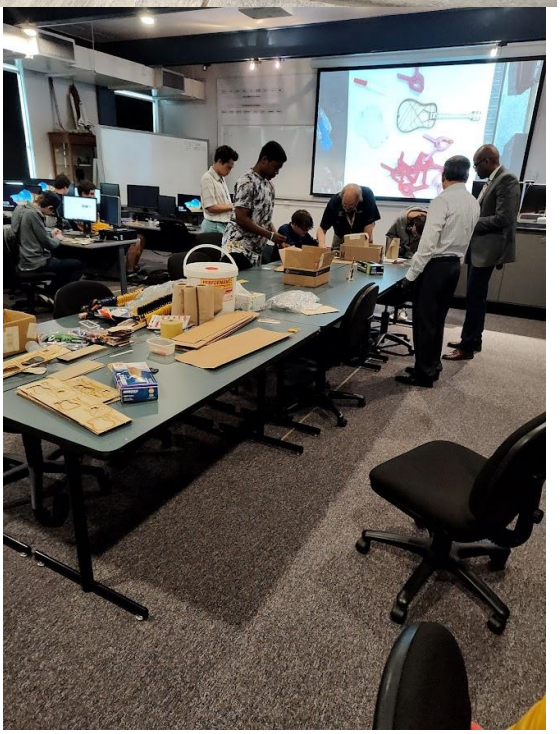


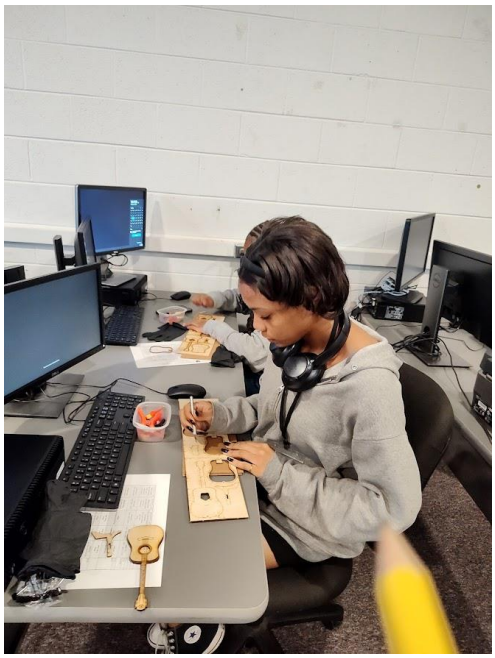
Students got introduced to Eports and had to opportunity to use the Esports Lab during their free time

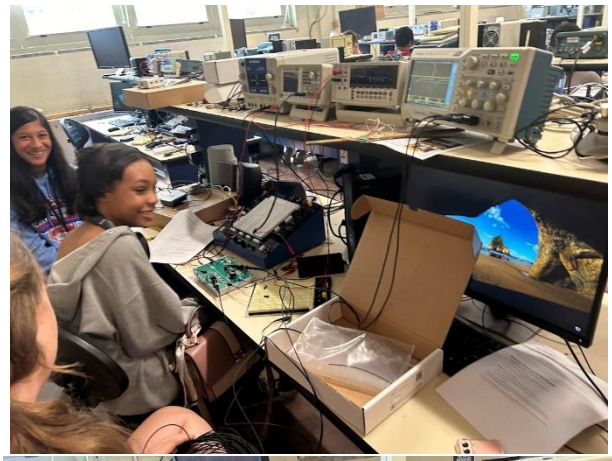


We had a mix of students from different schools and backgrounds and thus activities were designed to build friendships and inclusion

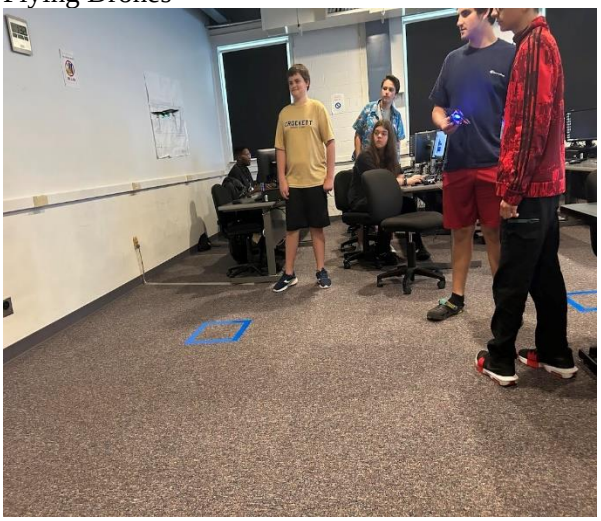


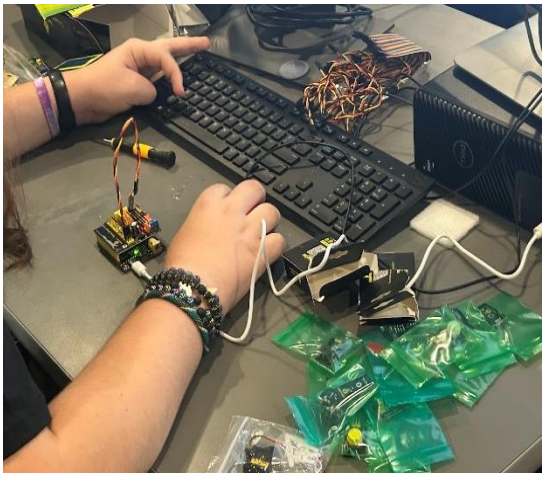


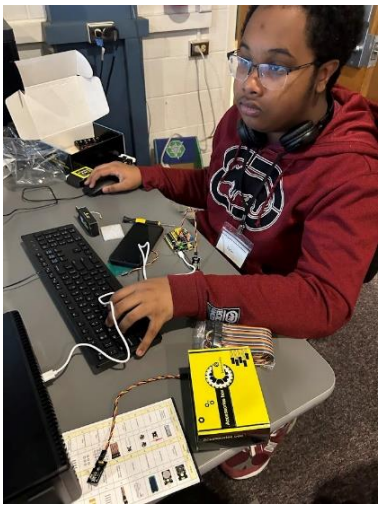


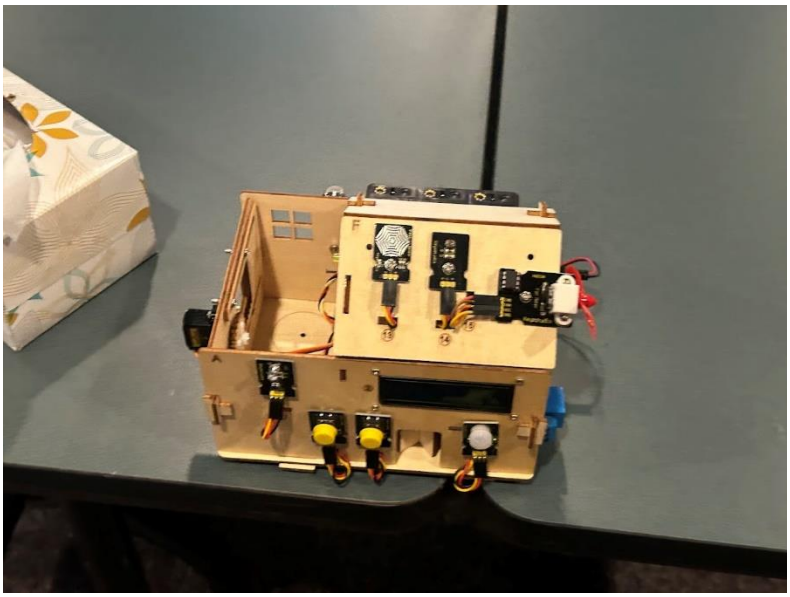


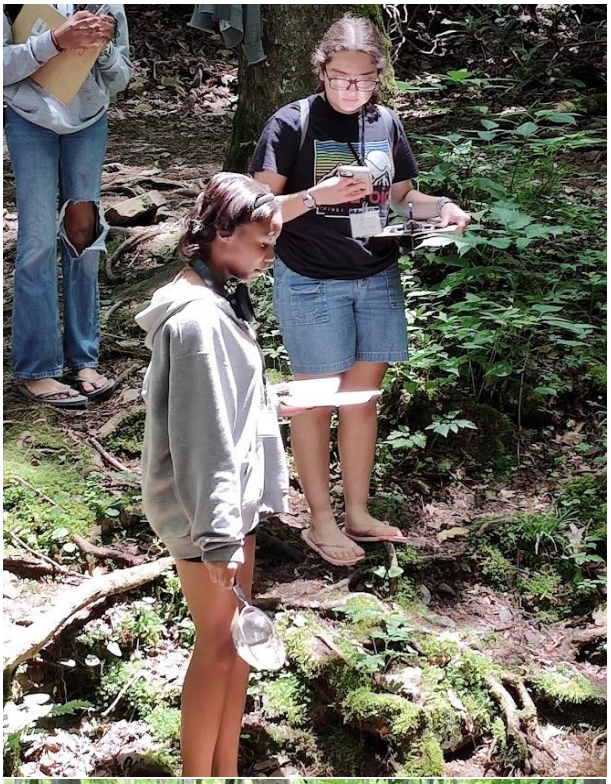
Flying Drones





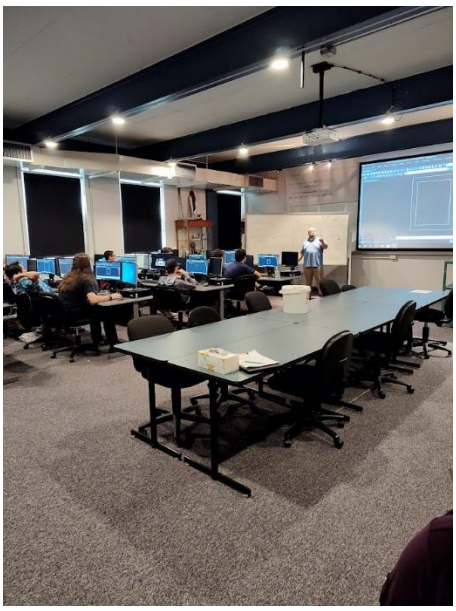






Presenters from the Tennessee Council on Developmental Disabilities talk with the students on how technology has impacted people with disability and allowed them to be more independent.


HOW DO REMOTE SUPPORT TECHNOLOGY SOLUTIONS WORK?




welcome to
day 3!
today's lesson:
Level Design and recoding
with Ren
(This Pc>Data(D:)>2024_Summer>Into_Unreal_Morn)