The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
Paper ID #43190

Board 146: Enhancing STEM Education through Engaging Summer Programs: A Multi-Faceted Strategy

Tala Katbeh, Texas A&M University

Tala Katbeh is a STEM Instructor and Program Coordinator at Texas A&M University at Qatar (TAMUQ) where she applies her knowledge and enthusiasm for engineering to create curricula and engineering courses for school students. Katbeh is currently also pursuing her PhD at Texas A&M University, having graduated from TAMUQ with a BSc and MSc both in chemical engineering.

Mr. Gerald Benjamin Cieslinski, Texas A&M University at Qatar

Assistant Director of STEM Outreach

Hassan Said Bazzi, Texas A&M University at Qatar

Dr. Hassan S. Bazzi is the senior associate dean for research and advancement and professor of chemistry at Texas A&M University at Qatar, a branch campus of Texas A&M University. Dr. Bazzi is also professor of materials science & engineering at Texas A&M University. Dr. Bazzi received his bachelor's and master's degrees in chemistry and organic chemistry, respectively, from the American University of Beirut (1996 and 1998), and his Ph.D. in polymer chemistry with Dean's Honor List from McGill University (2003). He worked briefly with the United Nations as a chemical weapons inspector in Iraq before doing a postdoctoral research fellowship at Université de Montréal. He joined Texas A&M at Qatar as assistant professor in 2004, was promoted to associate professor (2009), and then to full professor (2014). Dr. Bazzi completed the Management Development Program (June 2014) and the Institute for Management and Leadership in Education (June 2018) at Harvard University Graduate School of Education.

Syed Mustafa Husain Abidi, Texas A&M University at Qatar

Enhancing STEM Education through Engaging Summer Programs: A Multi-Faceted Approach (Evaluation)

Abstract

As the world increasingly relies on STEM (science, technology, engineering, and mathematics) innovations, it is essential to prepare the next generation of pioneers. This paper explores the dynamic landscape of STEM education, with a specific focus on the structure and delivery of four distinct summer programs. These programs – centered around various innovative engineering domains: 3D CAD modeling, REV robotics, engineering design and innovation, and Pinewood Derby® design – provide students with immersive, hands-on experiences that extend beyond traditional classroom settings, developing and encouraging critical thinking, creativity, collaboration, and practical skills. Each program is meticulously structured to maximize educational impact. The 3D CAD modeling program provides students with a hands-on exploration of computer-aided design, empowering them to create tangible designs and visualize the interplay of form and function. The REV Robotics program immerses students in the world of robotic systems, emphasizing collaborative problem-solving skills and bridging the gap between classroom theories and practical applications of robotics. The engineering design and innovation program teaches students the entire engineering design process, from conceptualization to prototyping, and places significant emphasis on teamwork and effective communication. The Pinewood Derby® design program combines valuable lessons in engineering, aerodynamics, physics, and craftsmanship within a well-structured framework, as students design and race their own cars. The programs emphasize the importance of hands-on learning, critical thinking, innovation, and collaborative teamwork, which are essential skills for success in the STEM field. This paper emphasizes the structured and engaging delivery of these summer programs in shaping the future of STEM education. The structure is purposefully designed to not only provide students with practical skills but also to instill a passion for STEM fields as they create a pathway for future innovators, engineers, and scientists by expanding the students' horizons. Through these programs, students gain a deep appreciation for the synergistic power of diverse perspectives and skills, cultivating a new generation of innovative thinkers and problem-solvers.

Keywords: STEM education; 3D CAD modeling; robotics; engineering design; pinewood derby; summer programs

1. Introduction

In the rapidly evolving landscape of education, STEM (science, technology, engineering, and mathematics) has emerged as a cornerstone for fostering critical thinking, innovation, and problem-solving skills. As societies increasingly rely on technological advancements and innovations to tackle complex challenges, the cultivation of a proficient and competent generation becomes imperative. To this end, the utilization of engaging summer programs at Texas A&M University at Qatar represents a pivotal strategy in preparing the next generation of STEM pioneers in the region. In recent years, there has been significant growth in STEM education in Qatar, marked by the introduction of several innovative models [1-8]. This paper delves into the dynamic realm of STEM education, with a particular emphasis on the transformative impact of four distinct and successful summer programs. These programs, designed to immerse students in hands-on experiences beyond the confines of traditional classroom settings, serve as catalysts for the development of critical thinking, creativity, collaboration, and practical skills essential for success in STEM disciplines while also exposing them to real-life applications.

Recent pedagogical shifts have emphasized the importance of experiential learning and hands-on activities in promoting meaningful engagement and knowledge retention among students. By providing students with opportunities to apply theoretical knowledge in real-world contexts, such approaches bridge the gap between academic learning and practical application, thereby preparing students for success in STEM-related professions. By encouraging peer interaction and collaboration, summer programs can create synergistic learning experiences wherein students leverage diverse perspectives and skill sets to tackle complex challenges [9].

Within this context, a set of engaging and transformative summer programs have been developed, offering students the opportunity to be exposed to various engineering disciplines. As an institution that offers engineering education to students in Qatar, the programs developed by the outreach team at Texas A&M University at Qatar are geared towards concentrating on the engineering aspect of STEM education while incorporating science, technology, and mathematics to develop a holistic and robust educational program. By offering hands-on experiences in 3D CAD modeling, REV Robotics, engineering design and innovation, and pinewood derby design, these programs provide students with opportunities to engage deeply with engineering concepts that are exciting in nature while honing essential skills that enable student success in both the short and long-term.

The outlined model comprises of four advanced STEM courses:

i. **3D CAD Camp**. In this program, students learned the basics of 3D modeling, including designing, creating, modifying, and evaluating their 3D creations; moreover, they were simultaneously linking the significance of 3D models in engineering and the 3D printing process as they built their own models.

ii. **REV Robotics Camp**. Through this program, students gained the fundamentals of mechanical and electrical engineering where they designed, built, and programmed their own robots from the professional grade REV robotics kits used in well-renowned international competitions.

iii. **Qatar Invents!** This program allowed students to understand the foundations of the engineering design process where they were tasked with inventing novel solutions to real-world problems.

iv. **Pinewood Derby® Engineering**. This program helped in merging various science and engineering concepts with a time-honored tradition: the pinewood derby. Students used science and physics to engineer their own cars from a simple block of wood by combining topics on potential and kinetic energy, friction, air resistance, weight distribution, and statistics to race their cars.

These programs not only supplement classroom learning but also bridge the gap between theory and practice, enabling students to apply their knowledge in real-world scenarios through hands-on projects. In this paper, the multifaceted dimensions of these four distinct summer programs are outlined by examining their pedagogical approaches, student outcomes, and their comprehensive contributions to the advancement of STEM education.

2. General Program Structure

The proposed programs can either be administered externally through STEM centers or internally integrated within schools, allowing schoolteachers the flexibility to tailor the program structure according to their academic schedules. Each of the four programs can be offered as a standalone workshop or as part of a continuous month-long engineering camp. For this study, the program was offered to different cohorts as individual workshops. This section highlights the general program structure implemented by the STEM outreach team at Texas A&M University at Qatar, and it was made available to all students across Qatar, with one program offered one week at a time over the summer break.

The implementation process for each program followed a systematic approach. Initially, promotional materials describing the program's objectives were disseminated to schools through direct communications and social media platforms. Subsequently, students were directed to register via an online platform, with Google Forms serving as a convenient and accessible registration tool. The registration application form includes questions to identify the students who demonstrate genuine interest and commitment to the proposed program and topic. The selection process is competitive since the large influx of applications are screened or filtered due to the limited availability of spots in the allocated STEM workspace. The applications are made available for each program and, depending on the students' age group and topic of interest, information is sent out to the students upon selection. A total of 30 students, representing schools from across Qatar, across multiple age range were selected to participate in each program which was held at Texas A&M University at Qatar's STEM Hub.

As for the programs' structure, each course consisted of daily sessions from 9:00 a.m. until 1:00 p.m. that ran over the course of five days. Lessons were then organized into daily modules, incorporating mini projects to reinforce learning and assess comprehension of the theoretical lessons. By the end of the program, a final project is announced that has students combine all the covered material throughout the week into a tangible product with a specified competition that serves as a motivator. Moreover, the students gain communication skills where they compete and present their work with expert panels judging the submitted projects and certificates of excellence are awarded to winning teams or individuals. Table 1 highlights a summary of the program structure and targeted age range.

Table 1: Targeted age range of students participating in the summer engineering programs.

Program Name	Age group (years)	Hours of Instruction (hours)
3D CAD Camp	High school (14-17)	20
Rev Robotics Camp	High school (14-17)	20
Qatar Invents!	Middle school (11-14)	20
Pinewood Derby Engineering	Middle school (11-14)	20

Details of the topics covered for the four programs are listed in the sections to follow with the lesson materials, required resources, and activities completed.

3. 3D CAD Camp

The 3D CAD modeling program provides students with a hands-on exploration of computer-aided design, a cornerstone of modern engineering. This week-long program blends theoretical concepts with practical application, where students learn to transform abstract ideas into tangible designs. By employing professional software, students are empowered to create intricate models, simulate complex processes, and visualize the interplay of form and function. The students were trained using Fusion 360, a professional CAD/CAM software that provides free educational licenses for students and educators. Beyond technical proficiency, the program emphasizes the cultivation of creative thinking and design innovation. Students embark on projects that challenge them to tackle real-world problems, fostering an iterative design process that mirrors the dynamic nature of professional engineering.

On the first day of the program, students learn the basics of technical sketching as a critical communication tool for engineers. Additionally, its importance in engineering, documentation, and coming up with novel inventions was highlighted as students covered various sketching exercises using isometric grids to convert multi-view sketches of an object into an isometric one. This enabled the students to visualize objects and be able to utilize 2D sketches as the first step to creating their 3D models. Figure 1 shows students working on a practice exercise on creating an isometric drawing from a multi-view sketch of an object.

The second lesson involved getting started on the 3D CAD software, Fusion 360. Understanding planes in 3-dimensional space helped them initialize and create their models. The engineering design process for this course was summarized in a relatable and fun method by the course instructor through a method called the “3 D’s”: define, design, and develop. This meant that the students must define the issue at hand that they want to solve through the designs they will create – they need to identify what it is that they want to design and what it is going to achieve. This then brings them to the design stage where they have to consider how it will look like to perform its function. Finally, the students develop their designs by creating the 3D models and determine the steps they need to make to achieve their target outcome. This technique was then used for the duration of the program as students worked on their projects.

Figure 1: Students working on a technical sketching exercise as a first step towards learning how to create 3D designs.

As the students worked on Fusion 360, the various functions, features, and tools that the software provides were introduced to the students as they all worked on different examples. The covered features included learning how to create initial sketches using the software, defining dimensions, and adding depth and various details using multitude of features.

Next, students were introduced to 3D printing which takes them "from design to production". They learnt about the various types of manufacturing, the different kinds of printers available and the materials used and were then taught how they can print their own models using the 3D printers that can typically be found in schools nowadays.

The program also consisted of two major projects, a mini project and a final project, to allow students to combine the individual lessons of the various functions of the Fusion 360 software. In the mini project, students were tasked with replicating famous artifacts used by superheroes in comic books as a relatable and motivating design to create. These included Batman's batarang, Thor's hammer, Green Lantern's ring, among others. This project allowed students to brainstorm the best approach to tackling the task of converting the image in-front of them to a 3D replica. Figure 2 illustrates various designs created by the students in this activity. The outputs of the mini project were then 3D printed and given to the students as a take-home token.

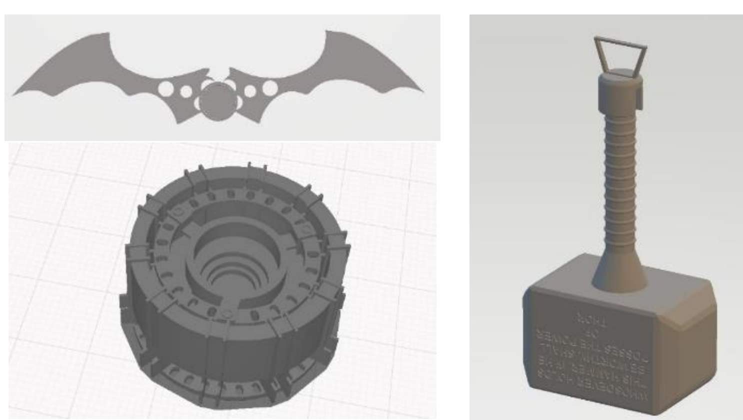

Figure 2: Various outputs of the mini project exercise showcasing Batman's batarang, Ironman's arc reactor and Thor's hammer.

The final project involved creating their own objects that can be utilized in their study spaces with various design criteria that enabled them to utilize all the features learned. In the mini project, the students had the results of their design in front of them beforehand as the final form of the designed objects were known to them. However, the final project took the opposite approach where the students were only provided with design requirements as statements, while the form of their design was an individual approach. The design requirements for the final project were as follows:

1. To be able to be placed on a study desk.
2. The design must conform to a size restriction of 125 mm x 125 mm x 125 mm as a limitation on the 3D printer build volume.
3. The design must be able to hold two-three pens/pencils and a phone with a slot in the bottom for connecting the charger.
4. The design must also hold three other objects of the designer's choice.
5. The design must have the designer's name added to the body using a fusion 360 feature.
6. The design must display the use of at least four distinct Fusion 360 features.

To aid students with their designs, concepts of engineering design process were incorporated in the discussions to allow students to go beyond the confines of 3D design and equip them with the required problem-solving skills to create functional designs. Figure 3 shows the students working on brainstorming different ideas for their designs and working on their 3D models. The students were encouraged to be creative with their designs while meeting all the defined design requirements. Figure 4 illustrates various designs created by the students in this activity.

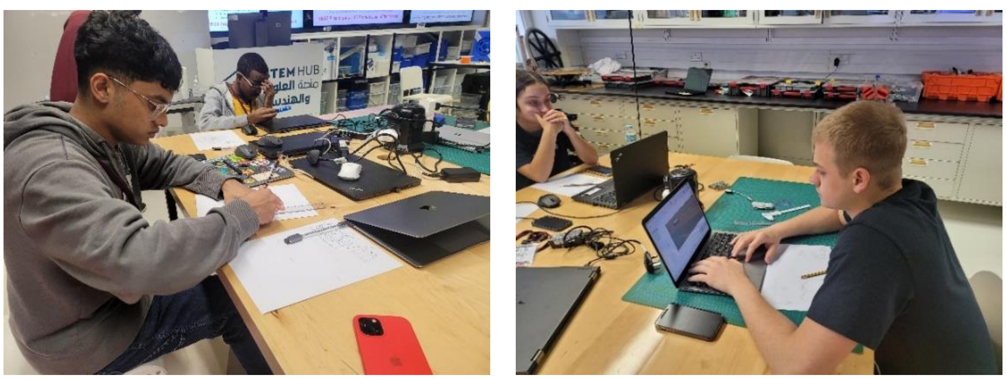

Figure 3: Students working on sketching their design ideas for the final project and creating the 3D models of their designs using Fusion 360

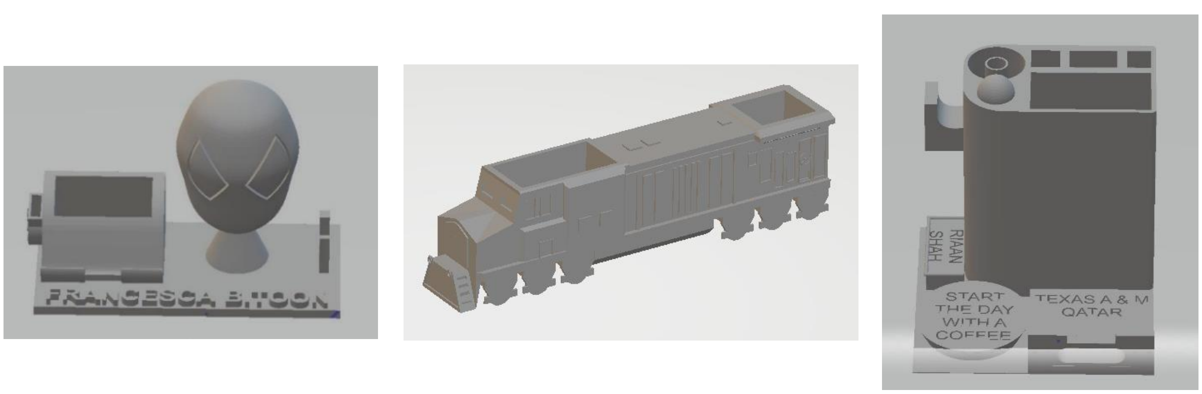

Figure 4: Various designs developed by students in the final project of the 3D CAD Camp

Students participating in the camp were highly motivated by the fact that they could see tangible results of the designs they came up with. The success of the program can be highlighted by the fact that many students contacted us to inform us of their use of their newly acquired skills in 3D modeling in their high school research projects which were implemented in various international competitions. Students were also using their skills to create sketches of their designs that they utilized to create robotics parts and for documentation of their designs in their technical reports in robotics competitions. Moreover, there were students that landed internships based on their newly acquired skills in 3D modeling. Seeing the outcomes of the program implemented in different areas among students in schools nationwide has demonstrated its effectiveness and success.

4. REV Robotics Camp

At the crossroads of technology and engineering, the REV Robotics program immerses students in the world of robotic systems. Through a combination of interactive workshops, hands-on building, and coding challenges, participants not only gain proficiency in robotics but also develop a holistic understanding of automation and mechanics. The program nurtures collaborative problem-solving skills, as students work in teams to engineer functional robots capable of performing intricate tasks. Moreover, the REV Robotics program provides a unique avenue for students to experience the excitement and challenges of engineering in action, bridging the gap between classroom theories and the practical applications of robotics in today's industries. This interdisciplinary branch combines several elements and disciplines such as electrical engineering, mechanical engineering, computer science, and art and design.

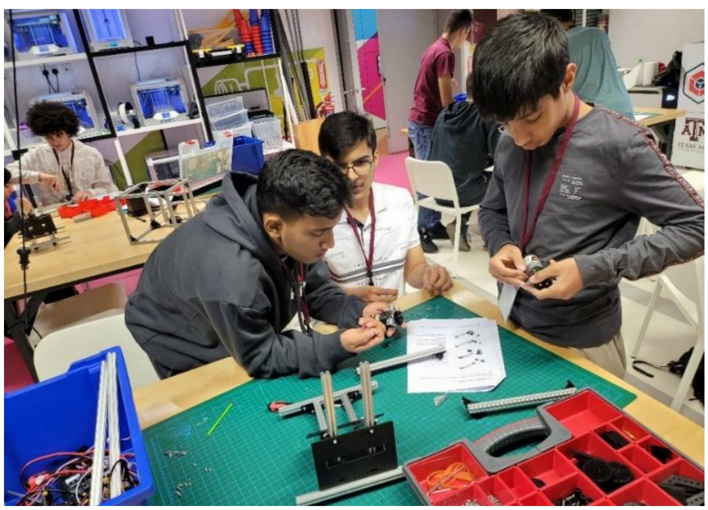

Figure 5: Students working in teams to build their robots.

During the first lesson, the students were split into teams to work together throughout the week to create functioning robots that will be able to complete the tasks for a final competition that will be held at the end of the program. With the competition as a motivator that created an interesting challenge for the students, the students were introduced to the fundamentals of robotics: the construction, design, application, and operation of robots. Once the students understood the typical components required to create robots (a movable structure, sensor system, brain or controller, actuators, and a power supply) the students utilized the REV Robotics kits. They were then tasked to design and assemble a robot with a functioning operation system to sense, have a plan they will program through an algorithm, and act accordingly based on the final challenge tasks. Instructions and tips were provided to the students so they could utilize the required tools to assemble different frames, screws, brackets, and motor mounts. Figure 5 shows a team working on their basic robot structure with all the required tools and materials.

On the second day, the students focused on designing and creating a robot that will accomplish all the required tasks for their competition that was held on the final day. The students were tasked with competing as teams in a final challenge that was based off the previous season's FIRST® Tech Challenge. The competition acted as a motivator to utilize the skills they learned to create the best possible design for their robots to achieve the required functions needed. This included designing a robot with a claw that can grasp and move the cones required for the challenge, an arm that will be able to maneuver the objects and lift the cones to place them on poles referred to as "junctions", a stable driving base with accurate design parameters to take into account the center of mass and proper functions for rotational motion. Moreover, the team members had to make sure they program the robots accurately to maximize the efficiency of the robot and ensure that they are able to control it with precision. The students simultaneously learned how to assemble the robot control system and create programs required to test the movements of the different parts of their robots through introductory lessons on programming using the Driver Station application required for the REV Control Hub (the robot controller).

On the third and fourth days, the students continued building their robots, creating modifications, and testing the different programming algorithms to optimize their designs. By the end of the fourth day, the students had completed their robots and codes, ran practice matches on the competition arena, and were ready to compete in the final challenge.

The REV Robotics Camp ended with an exciting competition that showcased the students' efforts and understanding of robotics that they have gained throughout the week. Figure 6 below shows one of the matches conducted where two alliances competed against each other with two teams per alliance that were randomly selected in a set of matches throughout the day.

Figure 6: The final challenge where teams competed using the robots they built and programmed.

This program had helped increase their collaborative problem-solving skills and teamwork. Moreover, this program helps us train and recruit students to the STEM Hub Robotics Club to participate in the FIRST® Global Challenge to represent the country internationally [1]. Additionally, the program enabled students with prior experience with robotics to volunteer their time to come back and join our programs but as student mentors to the teams and serve as judges and scorekeepers during the competition (as shown in Figure 6).

5. Qatar Invents: (Engineering Design and Innovation Program)

The engineering design and innovation program empowers students to explore the entire design process, from conceptualization to prototyping. Participants are immersed in an environment that encourages creativity, resourcefulness, and outside-the-box thinking. Through hands-on projects, students learn the value of iterative design, discovering that failure is an integral part of innovation. The program places significant emphasis on teamwork and effective communication, mirroring the collaborative nature of engineering projects in real-world settings. By working together to tackle complex challenges, students gain a deep appreciation for the synergistic power of diverse perspectives and skills.

The program started off by amplifying the importance of teamwork. Teams were created based on the students' skills set that were collected when students introduced themselves. Index cards were distributed to the students and their skills and interests were listed. The course instructors then divided the students into six teams depending on their interests such that the teams had diversity. Moreover, this program focuses on the importance of documentation especially because the students are taught the steps to creating an innovative engineering solution.

The engineering design process was covered and was then implemented throughout the program. The problem that was given to them to come up with a solution to was shared as a company proposal. A made-up delivery company was created, and the proposal included the company background as well as the problem statement and criteria which calls out for a team of engineers to design a product that will protect the safety of delivery drivers to keep them safe on the road. They were to develop a new innovative technology with features that focus on reducing the effects of the heat during the summer months. The teams had to then pitch their products to a panel of judges (from the supposed company) to select the winning bid.

The relevant lessons covered included lessons on the following: the history of cooling prior to air conditioning, how air conditioning works, evaporative cooling, heat transfer, refrigeration (Figure 7 shows students working together to explain how refrigerators work with a sample mini-refrigerator and a lesson on how heat is transferred). Finally, the students learned the tips and tricks to presenting and communicating their ideas by learning how to create elevator pitches.

Figure 7: Students understanding refrigeration.

To tackle the problem, students learned the fundamentals of brainstorming and how to create decision matrices to select the best solutions. Various brainstorming exercises were created using interactive methods as shown in Figure 8. Students wrote down all possible solutions that will help them come up with designs for their products that will help solve the challenge at hand. Group discussions were made, and ideas were merged to create the most feasible design.

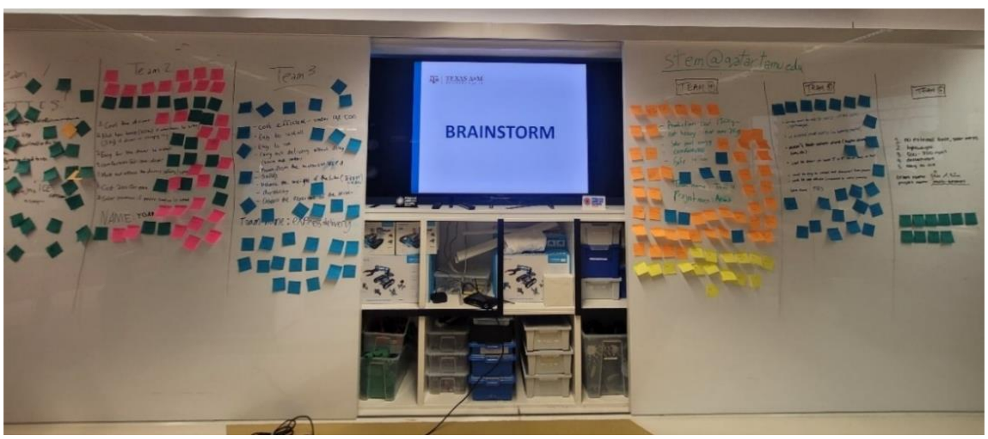

Figure 8: The outcome of the interactive brainstorming session in coming up with ideas and identifying and narrowing down the solution.

Students then defended their designs to a panel of judges where each team created prototypes and presentations of their designs (as shown in Figure 9).

Figure 9: Students with their inventions following their product pitches to the panel of judges

6. Pinewood Derby® Engineering Program

In a departure from traditional STEM offerings, the pinewood derby design program infuses STEM concepts into a classic activity. Participants engage in designing, building, and racing pinewood derby cars, applying engineering principles to a recreational pursuit. Beyond the thrill of the race, the program imparts valuable lessons in craftsmanship, aerodynamics, and physics. Students learn firsthand that even a seemingly simple activity involves intricate problem-solving and optimization. The pinewood derby program underscores the notion that STEM education can be seamlessly woven into everyday experiences, making it accessible and engaging for all.

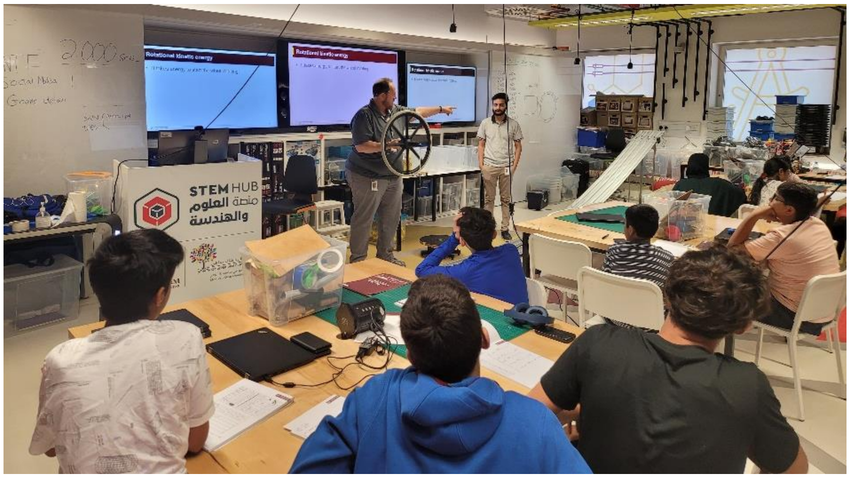

Figure 10: Students learning about energy and forces.

Through various lessons (as shown in Figure 10) on potential and kinetic energy, friction, air resistance, weight distribution, and statistics, the students understood the underlaying science behind the engineering of fast cars. Students also learned beyond the race – they gained lessons in failure and improvement. They were tasked with trying to create a design that increases drag and the target was to make their cars slow down by understand what techniques and method lead to failure and how they can improve the speed of their cars using the lessons covered throughout the program. Trials were made and their race timings were recorded to create averages so they can make comparisons with the different variables they changed. This included creativity, customization, and gaining practical skills.

The students utilized the theory to file, sand, and built the cars with the best aerodynamics as depicted in Figure 11. Various tests were made and recorded to compare the controlled or variable changes they made.

Figure 11: Students finalizing their car designs

On the final day, the cars were put to the test as they raced against each other to see how the changes they were working on over the past week impacted their cars' speed (as shown in Figure 12).

Figure 12: The final race

7. Measuring Impact and Benefits

Amid the diversity of the programs, several interconnecting themes emerge. Each program places a strong emphasis on hands-on learning, recognizing its transformative impact on knowledge retention and skill development. Moreover, critical thinking is a common thread, woven into the fabric of every activity as students grapple with challenges that require analytical reasoning. The programs also share a commitment to nurturing innovation, providing students with the tools and mindset to explore uncharted territories and propose novel solutions. Equally important is the cultivation of collaborative teamwork, a skill that not only fosters a sense of camaraderie but also mirrors the professional dynamics of the engineering field. These themes collectively underscore the symbiotic relationship between the programs and broader STEM education objectives.

The impact of these summer programs reverberates far beyond their immediate duration. Each of the summer programs enabled students to explore various individual interests and enabled students with different tangible skills that they could deploy in their own growth as potential engineers of the future. Students' testimonials bear witness to the transformative power of these experiences, recounting personal growth, newfound passions, and the development of skills that transcend the boundaries of academia. Engagement in these programs sparks a genuine interest in STEM fields, encouraging participants to consider potential career paths they might not have otherwise explored. As students embark on their educational journeys, the seeds sown during these summer programs continue to flourish, equipping them with a strong foundation and a unique perspective that sets them apart in an increasingly competitive landscape. Additionally, these programs extend their reach into the community, acting as catalysts for increased engagement and awareness about the significance of STEM education in shaping the future. Students also recognized the significance of engaging in practical hands-on activities within an exceptional workspace offered in the university facility as a crucial aspect of their learning experience. Since the commencement of these programs in 2016, approximately 30% of incoming freshmen to Texas A&M University at Qatar had previously participated in these outreach programs. Moreover, almost 40% of the university's applicants have taken part in the various programs offered by the university's STEM outreach department (this data has been collected between 2016-2022).

The success of these programs had led to the strengthening of community engagement and outreach where the Ministry of Education and Higher Education showcased their interest in collaborating with workshops and competitions. Various teacher training workshops have been conducted to help spread knowledge throughout the community. Additionally, these workshops have resulted in enhanced engagement and interest in STEM fields. These include the renowned VEX, TETRIX, and REV robotics programs, SeaPerch (the underwater robotics program), participation in the FIRST Global Challenge, and involvement with the Ministry of Education and Higher Education's National Innovation Olympiad (NIO). Many of the students come back as volunteers for the programs and get admitted to the university to become future engineers. One of the student volunteers for the Pinewood Derby Engineering Program that was a former participant in previous years stated: "I have had the unique opportunity to witness firsthand the transformative impact that the STEM programs have on students. Being on both sides of the program, I have seen how it not only equips students with technical skills but also fosters confidence, teamwork, and a passion for learning. Volunteering has allowed me to give back to a program that played a pivotal role in shaping my academic and personal growth. It is incredibly rewarding to see students' faces light up when they conquer a challenge or discover a new interest in engineering topics. I am grateful for the chance to pay it forward and inspire the next generation of innovators and problem-solvers especially as a current engineering student in Texas A&M University at Qatar."

The programs are equipping students for future career pathways with projects of real-world relevance that they are using in their day-to-day lives and in their education. One student claimed that "participating in the 3D CAD Camp not only taught me technical skills but also instilled in me the confidence to tackle complex problems and pursue a degree in engineering". Another student mentioned that "a STEM program like the REV Robotics Camp is crucial for showing students the real-world applications of what they are learning in the classroom. It's one thing to read about engineering concepts, but it's another thing entirely to build and program a robot in one week that can navigate an obstacle course that is used in international competitions. The mentorship I received was invaluable and the skills I have gained help me think critically, solve problems creatively, and adapt to new challenges."

We have encountered and been approached by several students that participated in these programs in other design, innovation, and research competitions to showcase the skills they have learned with us and how they have utilized them in their projects. From creating 3D models of different prototypes, to the engineering design process and documentation, to implementing the topics they learned that inspired their innovative inventions, to working well in teams and becoming great presenters, the students went on to partake in national and international eminent competitions. This included the ITEX (International Invention, Innovation, Technology Competition and Exhibition), ISEF (International Science and Engineering Fair), and NIO (the National Innovation Olympiad).

While the success of these programs is evident, opportunities for growth persist. Ensuring diversity and inclusivity remains an ongoing endeavor, with a focus on creating an environment that welcomes individuals from all backgrounds and experiences. As technological advancements reshape industries, the programs must adapt to incorporate emerging trends and technologies to maintain their relevance. A commitment to continuous improvement is essential, as each program seeks to refine its curriculum, teaching methods, and learning outcomes. Efforts to expand program accessibility through scholarships, partnerships, and community outreach will further enhance their impact, ensuring that the benefits of engaging STEM education are accessible to a wider spectrum of students. Future studies include application, retention, and matriculation of participating students to Texas A&M University at Qatar or other universities for STEM related education.

8. Conclusion

In conclusion, the transformative potential of STEM education is vividly embodied in the multidimensional experiences offered by these four summer programs. By seamlessly integrating theoretical concepts with practical applications, fostering creativity, promoting collaboration, and imparting real-world relevance, these programs pave the way for a new generation of engineers, innovators, and critical thinkers. As the global demand for STEM professionals continues to escalate, these programs exemplify the power of immersive, hands-on education in preparing students for the challenges and opportunities that lie ahead. By nurturing curiosity, igniting passion, and honing skills, these programs not only enrich students' lives but also contribute to the larger tapestry of scientific and technological advancement. Ultimately, they serve as beacons of inspiration, guiding students towards a future where the boundaries of possibility are limited only by their imagination and determination.

9. References

[1] T. Katbeh, G. Cieslinski, and H. Bazzi, "Promoting STEM Education through the Preparation of Multicultural National Robotics Teams in Qatar (Evaluation)," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 43987. doi: 10.18260/1-2--43987.

[2] B. Cieslinski, M. Gharib, B. Creel, and T. Katbeh, "A Model Science-Based Learning STEM Program," in *Volume 5: Engineering Education*, Salt Lake City, Utah, USA: American Society of Mechanical Engineers, Nov. 2019, p. V005T07A016. doi: 10.1115/IMECE2019-10352.

[3] G. Cieslinski, T. Katbeh, and H. S. Bazzi, "Keeping Cool with Qatar Cool: A Pre-College Education Program Emphasizing Corporate Regional Engineering with Hands-On STEM Learning (Resource Exchange)," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 44008. doi: 10.18260/1-2--44008.

[4] G. Cieslinski, T. Katbeh, and H. S. Bazzi, "Creation of a Mobile Science and Engineering Road Show for Texas A&M University at Qatar: Multicultural STEM Education and Entertainment (Resource Exchange)," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 42825. doi: 10.18260/1-2--42825.

[5] M. Gharib, B. Cieslinski, B. Creel, and T. Katbeh, "A Model Engineering-Based STEM Learning Program," in *Volume 5: Engineering Education*, Salt Lake City, Utah, USA: American Society of Mechanical Engineers, Nov. 2019, p. V005T07A017. doi: 10.1115/IMECE2019-10360.

[6] M. Gharib, T. Katbeh, G. B. Cieslinski, and B. Creel, "An Integrated Engineering Agriculture STEM Program," in *Volume 9: Engineering Education*, Virtual, Online: American Society of Mechanical Engineers, Nov. 2020, p. V009T09A028. doi: 10.1115/IMECE2020-23584.

[7] M. Gharib, T. Katbeh, G. B. Cieslinski, and B. Creel, "A Novel Trilogy of e-STEM Programs," in *Volume 9: Engineering Education*, Virtual, Online: American Society of Mechanical Engineers, Nov. 2021, p. V009T09A041. doi: 10.1115/IMECE2021-69012.

[8] G. Salama *et al.*, "Illustrating Engineering Education: A Children's Book to Support STEM Outreach in Qatar," in *2019 IEEE International Conference on Engineering, Technology and Education (TALE)*, Yogyakarta, Indonesia: IEEE, Dec. 2019, pp. 1–5. doi: 10.1109/TALE48000.2019.9225947.

[9] T. Roberts *et al.*, "Students' perceptions of STEM learning after participating in a summer informal learning experience," *Int. J. STEM Educ.*, vol. 5, no. 1, p. 35, Dec. 2018, doi: 10.1186/s40594-018-0133-4.