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Building the Pipeline: STEM Summer Camps and the Path to Gender Equality in Engineering

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Abstract

In this paper on innovative practices, we explore the development and outcomes of Girls Summer Engineering and Technology (GirlSET), a STEM summer camp, first launched in 2017. The women faculty in engineering and computer science noticed underrepresentation of female students in technology-based fields. To break down the barriers, GirlSET was designed as a female-centered summer camp, created by women for women. The initiative aims to introduce and inspire young girls aged 14-17 to engineering and computer science, with the goal of fostering a positive mindset towards STEM careers. Originally conducted in person, GirlSET adapted to an online format during the COVID-19 pandemic and returned to an in-person experience in 2024. The camp has successfully run for eight years, engaging young girls through targeted activities and mentorship. In this paper, we report on the insights gained from implementing GirlSET and the impact it has had on participants' perceptions of STEM fields, equipping them with techniques to drive innovation and make a difference in society. We provide detailed examples of activities designed to spark interest in various engineering disciplines and discuss the outcomes observed over multiple camp sessions. These sessions include hands-on challenging interactive in-lab activities in nine different areas of engineering, presentation sessions from the final year engineering and computer science students working on their capstone projects, interactive sessions with female role models in the industry, and panel discussions with women-in-engineering students. Introducing girls to different engineering disciplines and how engineering can be used to address daily life problems engages their different mindsets in the problem-solving process of developing better solutions. The GirlSET summer camp offers a roadmap for other institutions seeking to implement similar initiatives to increase female enrollment in STEM. We aim to contribute to the broader conversation on diversity in engineering education and inspire more universities to support the next generation of women in STEM.

Keywords: engineering education, STEM summer camp, women in engineering, diversity in STEM, gender equality in STEM

1- Introduction

In both Canada and the United States, women make up roughly half of the workforce but are significantly underrepresented in advanced technology sectors. In 2024, women comprised 47% of the workforce in Canada, but their representation in STEM fields was less than 25%. Similarly, in the United States, women made up only 27% of the STEM workforce [1]. This disparity highlights the urgency of fostering early interest and sustained engagement in STEM among young girls, particularly through initiatives that emphasize hands-on learning and mentorship opportunities. Moreover, women are vastly underrepresented specifically in engineering and computer science sectors. Percentage of newly licensed professional engineers who are women is 20.2% nationally in Canada in 2023 [2]. The 30 by 30 initiative, conceived by the Association of Professional Engineers and Geoscientists of Alberta and adopted by Engineers Canada in 2010, aims to increase the number of women engineers in the workforce to 30% by 2030 [3]. Special efforts are to be made to attract women into the engineering profession.

This lack of representation at the professional level is often mirrored at the educational level, where girls continue to show lower levels of interest in pursuing engineering as a career. Programs designed to inspire middle and high school female students to envision themselves in engineering and computer science careers play a critical role in bridging this gap. Many existing initiatives focus primarily on undergraduate or high school students, leaving a gap in programs specifically designed to engage and inspire younger female students at a critical stage of their educational development. Addressing this gap is essential to creating a pipeline of future women engineers.

That is why the faculty of the Gina Cody School of Engineering and Computer Science at Concordia University conceptualized and implemented GirlSET summer camp in 2017- a two-week summer camp tailored to address these unique challenges and inspire middle and high school female students to pursue careers in engineering and computer science.

The primary goal of GirlSET summer camp is to encourage interest in the engineering field among young women aged 14-17. This two-week program introduces girls to engineering and other STEM fields, which are often perceived as male dominated. The program's mission is to inspire and empower young women to explore careers in engineering and computer science by providing exposure and hands-on experience through practical activities and industry sessions. Participants are mentored by distinguished engineering students, technical staff, and faculty members from the Gina Cody School of Engineering and Computer Science. The program begins with an address by Dr. Gina Cody, the first female PhD graduate from the construction engineering program. It continues with a series of hands-on activities across various domains of engineering and computer science, visits to multiple labs within the Gina Cody School, and industry sessions led by women in different engineering fields.

2- Related Works

Several initiatives have been considered to integrate engineering education into the K-12 curriculum. While there is some caution regarding the timing of early exposure, one key argument for this integration is that it could spark interest in engineering and better prepare students for a career in the field [4].

Existing initiatives, such as Educate to Innovate [5], are already working to expose girls and young women to STEM fields. Programs like the Department of Energy's Women in STEM [6] mentoring initiative connect undergraduate female students in the Washington, DC area with mentors in their respective subject areas. This program also encourages participants to mentor high school and elementary school students. Similarly, the WitsOn (Women in Technology Sharing Online) program [7], launched by Harvey Mudd College in 2012, connects female STEM undergraduates with mentors from both industry and academia.

In 2007, the University of Virginia initiated a program where Engineering Teaching Kits were designed, implemented, tested, and distributed to middle school science and math classes. The program, run throughout the year, tested twenty-two kits in local middle schools [8]. A similar program, Sooner Elementary Engineering and Science [9], started as an after-school initiative for elementary students and was later expanded to include college student involvement. A separate initiative, led by the University of Rhode Island [10], involved the design and implementation of an Educational Outreach Chemistry Camp specifically for middle school girls.

Another noteworthy program, Black Girls Code [11], raises awareness and provides skills, resources, and opportunities to girls aged 7-17. This program partners with schools, local organizations, and companies to offer in-person and virtual hands-on activities.

Within Canada, initiatives like STEM Village [12], based in Toronto, provide online education tools to improve skills in STEM areas, while Engineering for Kids [13] offers after-school programs, summer camps, weekend workshops, and special events for students aged 4-14. In

Montreal, the Technovation [14] program targets girls aged 8-18 and focuses on developing technological and entrepreneurial skills through a mobile application creation competition. Go CODE Girl [15] is another summer camp for girls (aged 7-11 years) that teaches coding and software development. The camp is hosted by universities across Ontario, Canada.

Despite the existence of these initiatives, a notable gap persisted in Canada, particularly for middle and high school female students. At this critical stage of their education, many young girls lack opportunities to explore the diverse fields of engineering and develop a deeper understanding of its practical applications. Unlike university-level programs, which often emphasize hands-on experiences and multidisciplinary approaches, middle and high school students are rarely exposed to engineering in ways that connect theory to real-world problem-solving. This lack of exposure can limit their ability to envision themselves as future engineers and reduces their interest in pursuing STEM careers. Recognizing this gap, the women faculty at Concordia University's Gina Cody School of Engineering and Computer Science launched GirlSET to address this issue and inspire more young women to pursue careers in engineering. A key feature of this camp was its multidisciplinary approach, exposing participants to nine different areas of engineering through hands-on activities, lab visits, showcases of selected Capstone projects, and industry-led sessions. Additionally, the camp aimed to raise awareness about the gender gap in engineering by hosting Women in Engineering panel discussions.

3- Program Design and Implementation

The GirlSET summer day camp, designed as a two-week program, introduces girls to various areas of engineering and computer science, and benefits from strong support from multiple stakeholders, including faculty members, university students, and lab staff. Industry sessions are also incorporated, where women in engineering share their experiences and challenges to inspire participants to pursue careers in STEM. Additionally, participants are introduced to various non-academic STEM activities available on campus, such as student clubs and other organizations.

One of the key features that distinguishes GirlSET from private STEM camps is the inclusion of capstone projects and interactive sessions with final-year engineering students. These capstone projects provided the participants with a unique opportunity to witness the culmination of years of study and research within the STEM fields. By engaging with these projects, the girls gain valuable insight into the real-world applications of STEM knowledge and experience firsthand how students can apply their learning to tackle complex, multidisciplinary problems. Through these sessions, the participants not only observe the technical aspects of the projects but also understand the collaborative and problem-solving skills required to develop and implement solutions. They are exposed to how engineering and computer science students integrate knowledge from various disciplines to create innovative solutions that address pressing global challenges, such as environmental sustainability, healthcare, and technological advancements. By witnessing these capstone projects in action, the participants better visualize their potential career paths and the exciting opportunities that await them in the STEM field.

All in-person activities took place in the engineering and computer science labs at the Gina Cody School, and were led by students and staff from the school. The activities proposed by the faculty varied each year, giving participants the opportunity to register for future camps and experience new activities. The GirlSET summer camp offered a no-cost registration process before and during the COVID-19 pandemic, which evolved over time with a nominal fee in the post-COVID period to ensure better traceability and to encourage greater participant commitment.

During the two weeks of the program, the camp schedule was designed to include at least two activities per day, with a lunch break in between. If an activity had a shorter duration, additional activities were incorporated. The following section outlines the structure and evolution of the GirlSET camp.

3.1 – Initial Development (2017 -2019)

The GirlSET summer camp began in 2017 with 36 participants, introducing a variety of STEM activities. Week 1 focused on foundational engineering concepts, such as bridge building, synthetic biology, and solar-powered house construction, incorporating a sustainability aspect. Week 2 delved into more advanced topics like game development, website creation, and 3D printing. In 2018, enrollment more than doubled to 76 participants. To accommodate the larger group, the organizers divided the students into juniors and seniors, tailoring activities to each group's skill level. These included green concrete experimentation, data analytics, and aerospace engineering. By 2019, enrollment reached 89 participants, and the same division into two groups continued to ensure better engagement. New activities included Sumo-Bots, mobile app development, and renewable energy systems, with additional activities provided by Space Concordia.

Following the success of GirlSET in 2017, the Senate of Canada invited the GirlSET organizer to participate as a panelist at their Senate Open Caucus on Women and Girls in STEM in February 2018. This invitation was in recognition of the International Day of Women and Girls in Science and provided a platform for discussing barriers that prevent women and girls from studying and entering STEM fields, as well as what steps Canada can take to ensure equal opportunities for women and girls in scientific careers.

3.2 – Evolution During Covid-19 (2020 -2023)

From 2020 to 2023, the GirlSET summer camp transitioned to a fully virtual format in response to the COVID-19 pandemic. Despite the challenges posed by remote delivery, the camp organizers remained committed to providing high-quality STEM education through engaging activities. Unlike previous years, the camp was restructured into a single section that encompassed a diverse range of interactive and intellectually stimulating activities. Topics explored included "Does engineering have a gender?", where participants delved into the gender dynamics within the engineering field, and practical problems like penny battery construction and optimizing snow removal in Montreal, encouraging creative problem-solving.

The activities covered advanced topics such as AI for language processing, microcontroller applications, electrical engineering innovations, and the role of AI in manufacturing. Additionally, students were exposed to emerging technologies through sessions on smart doors, health app development, and building the metaverse using mixed reality. These sessions allowed students to engage with cutting-edge technology, providing them with an understanding of how modern engineering solutions are shaping the world.

Due to the restrictions on access to Concordia's facilities during the pandemic, students worked on projects using materials they had collected from home. To ensure that students could still fully engage with these activities, various simulation tools were employed to make the hands-on learning experience more tangible and interactive. This virtual format also made the program more accessible to participants beyond the province, allowing a broader range of students to benefit from the GirlSET experience.

3.3 – Return to in-person (2024 onwards)

In 2024, the GirlSET summer camp returned to its original in-person format, following the virtual transition during the pandemic. The shift back to in-person sessions allowed for the integration of more advanced and interactive sessions. After gaining more comfort with technology, participants were introduced to complex topics such as Artificial Intelligence and Virtual Reality. The camp covered a broad spectrum of STEM areas, with students exploring fields like medical imaging, autonomous robots (Sumo-Bots), space engineering, game development using Scratch coding, and 3D printing. Creative experiments, such as building potato batteries and hands-on soldering, further sparked participants' interest in engineering and technology.

The camp also included industry sessions that exposed participants to real-world engineering professionals, and a two-part bridge building and testing competition encouraged teamwork and problem-solving. To ensure an engaging and supportive learning environment, panel discussions were held with current women in engineering students, where participants could offer feedback on their experiences and gain insight into the diverse pathways in STEM.

Additionally, each section of the camp included different activities, making sure that students were exposed to various aspects of STEM, from theoretical discussions to hands-on experiments. This combination of industry exposure, interactive sessions, and feedback-driven learning helped reinforce the participants' understanding of STEM and encouraged them to explore potential career paths in these fields.

Table 1 presents the number of female student registrations since 2017 along with their demographic details, including the program's format (in-person or online) and participant distribution across Quebec, other provinces, and international locations.

Table 1: Number of participants and demographics

Year	Format	Quebec		Out of Province	International	Total Number of Participants
		English School	French School			
2017	In-person	15	20	1	0	36
2018		45	27	0	4	76
2019		22	63	4	0	89
2020	online	11	41	1	4	57
2021		22	47	4	6	79
2022		17	43	2	0	62
2023		26	9	2	4	41
2024	In-person	12	21	0	2	35

The next section provides a detailed description of a selected set of activities from different areas of engineering.

4 – Activities and Curriculum

Each year, the GirlSET activities are tailored to various technical sessions, including hands-on engineering projects in different engineering disciplines, computer science challenges, and collaborative problem-solving exercises. These activities are complemented by the integration of mentorship and role modeling, with significant contributions from women mentors from the Gina Cody School. Participants provided feedback on these activities, which, along with insights from mentors, is used to refine future programming.

GirlSET activities also include non-technical sessions that address underrepresentation of women in engineering, and how the new image of engineering will be shared by both men and women engineers. Having women camp facilitators as role models "eliminate stereotypes" and encourages different mindsets in the engineering profession.

Each activity is carefully structured to last no more than half a day, allowing at least two activities per day separated by a lunch break. Preferably led by women, these activities expose participants to diverse engineering fields, enabling them to explore and connect with the disciplines they resonate with. Activities facilitators are required to submit their proposed activities to the organizing team, who thoroughly review and approve them before implementation.

Tables 2 to 8 provide a brief description of a selected list of GirlSET activities from various areas of engineering. Selected photographs of the GirlSET activities from different areas of engineering are shown in Figure 1.

Table 2: Electrical and Computer Engineering

Name of Activity	Description
Designing a Robo Arm Controller	This online session introduces basics of electronics and robotics through four comprehensive modules. In the first module, participants explore key electronic components, learn circuit-building techniques, and program a microcontroller to control devices like LEDs. The second module utilizes TinkerCAD, where students design interactive circuits, including dancing LED lights and piano circuits, with real-time feedback from instructors. In the third module, participants design a simple robotic arm using a servomotor and potentiometer, reinforcing their hands-on understanding of prior concepts. The session concludes with a live demonstration and an interactive quiz contest, creating an engaging and impactful learning experience that foster curiosity in STEM fields.
Light Organ Assembly	This session introduces the principles of sound frequencies and their application in electronics through the assembly of a light organ circuit. Participants learn about the characteristics of low, middle, and high sound frequencies, and how they correspond to specific instruments or sounds. Using a soldering station and safety equipment, the girls assemble a circuit featuring a custom-designed PCB and various components, such as LEDs and a quad operational amplifier, under the guidance of experienced ECE technical staff and qualified student mentors. The light organ, which detects ambient sound via a microphone and lights up red, green, or blue LEDs based on frequency ranges, provides an interactive way to explore both sound and electronics. Each participant complete and test their own functional device, leaving the session with a fully assembled product and a memorable hands-on STEM experience.

Sumo-Bot Challenge	This session introduces fundamentals of electrical engineering and robotics through the assembly and operation of sumo-bots. Teams of two girls work with breadboards to wire pre-mounted components, including DC motors, line sensors, infrared rangefinders, and a motor-driver chip, following a detailed wiring diagram. After assembling and testing the circuit with jumper wires, the sensors are aligned to optimize performance. The activity culminates in an exciting sumo-bot competition, where teams pitted their robots against one another in a controlled arena. This engaging and hands-on project provide participants with practical experience in circuit prototyping, teamwork, and robotics, inspiring curiosity and confidence in STEM.

Table 3: Mechanical and Industrial Engineering

Name of Activity	Description
3D Printing for Additive Manufacturing	The 3D Printing session immerse participants in the fundamentals of design and fabrication, providing a hands-on introduction to additive manufacturing. Students explore the basics of 3D printing, how it works and its diverse applications in engineering, product design, and prototyping. Guided through the design process with 3D modeling software, the participants create their own parts ready for printing. Participants then witness their digital creations come to life as tangible objects, experiencing the practical process of transforming digital models into physical components. The session fosters creativity and problem-solving, inspiring participants to envision how 3D printing can address real-world challenges and drive technological innovation.
AI Data Set	Artificial Intelligence (AI) is revolutionizing industrial engineering, particularly in defect detection within manufacturing. By analyzing datasets from sensors, cameras, and production lines, AI models, such as convolutional neural networks (CNNs), can identify defects in real-time with remarkable precision. These systems use labeled data to learn patterns associated with faults, enabling accurate detection and prevention of defective products. During this session participants are shown how structured datasets can be fed into AI models to drive defect detection, highlighting its role in improving quality and efficiency.
Industrial Engineering can do anything	Industrial engineering is a versatile field that empowers innovation across countless domains, from manufacturing to healthcare and beyond. Its strength lies in optimizing systems through data-driven approaches and advanced tools like simulations. During this session, participants are introduced to simulation software like ARENA, where they are shown how to model and analyze physical systems virtually. By using these tools, scenarios are tested, outcomes are predicted, and complex problems are solved without real-world risks. This hands-on experience highlights the power of simulations in improving efficiency, reducing costs, and inspiring exploration of the endless possibilities within industrial engineering.

Table 4: Aerospace Engineering

Name of Activity	Description
Space Engineering Applications for Everyday Technologies (Space Concordia)	This session consists of 4 activities: Activity 1: Showcase + GCS Makerspace Safety Quiz At the beginning of this activity, half the group is provided with a comprehensive review of Space Concordia's projects, ranging from a 3u CubeSat (measuring 10x30cm) to a 42ft rocket. Space health's most recent parabolic flight, as well as robotics' CERES and the new drone project mimicking NASA's Mars rover Perseverance and Ingenuity, the helicopter, are also showcased. This introduction is designed to relate the activities to Space Concordia's projects by demonstrating the processes involved in sending something to space. In addition, the safety quiz for the GCS Makerspace is reviewed to ensure that

	everyone stayed safe during the upcoming sessions, which involved hazardous materials such as aluminum and solder. Activity 2: Machining Activity Conducted at the GCS Makerspace, participants are given the opportunity to create their own keychain using aluminum stock. Sheets of metal are engraved or stamped with letters and symbols, and the manual mill is used to poke holes for attaching the keychain along with a mini flashlight from the assembly and soldering session. This machining activity is inspired by the complete development of one unit of the CubeSat in the makerspace, which is manufactured from start to finish. Activity 3: Assembly and Soldering Activity Conducted at the GCS Makerspace, participants build and solder the electrical components of a mini flashlight. They are taught to strip wires, solder them to switches, and attach them to batteries. Afterwards, the 3D-printed pieces of the mini flashlight are assembled, and functionality is tested. This activity is related to Space Concordia in two ways: first, all electronics, such as PCBs, are designed and soldered in-house, and second, the wheels of the CERES rover were designed and 3D-printed using TPU at the makerspace. Activity 4: Embedded Programming Activity A coding portion for an embedded system is included in the activity to demonstrate how the brains of processes are created, and this is achieved by allowing participants to attempt the introductory task required to join the software teams of Space Concordia.
Apollo Challenge	The Apollo Challenge engages participants in an engineering design activity inspired by the Apollo 13 mission, fostering creativity, teamwork, and problem-solving. After watching a pivotal movie excerpt showcasing engineers devising a solution with limited materials, the girls learn about the design process in mechanical and aerospace engineering. Campers then tackle one of two challenges: virtually designing a device to suspend an egg above a circle without contact or physically creating a capsule to protect an egg from a two-story drop. Using limited materials like tape, paper clips, and elastics, participants work collaboratively to engineer innovative solutions. This activity emphasizes the principles of resourceful design and provide a fun, hands-on experience that mirrored real-world engineering constraints.

Table 5: Building and Civil Engineering

Name of Activity	Description
Bridge Building and Testing	This session introduces participants to structural engineering concepts through an engaging bridge-building competition inspired by the annual Troitsky Bridge Building Competition at Concordia University. Participants explore the design, construction, and testing of three bridge types: truss, beam, and arch. Using materials such as spaghetti sticks, popsicle sticks, wood chips, paper, dental floss, hot glue, and duct tape, teams work collaboratively to create miniature bridges. This activity emphasizes key principles of engineering mechanics, including load distribution, tension, and compression, while encouraging creativity and teamwork. Once completed, the bridges are tested for strength, with teams competing for both the strongest and most innovative designs. This hands-on activity provides participants with valuable exposure to teamwork, problem-solving, spatial reasoning, and experimentation, sparking interest in STEM fields beyond just civil engineering.
Water Treatment/Filtration	Two tests related to water quality and treatment: 1- Turbidity removal via coagulation-flocculation process. 2- Determining microbiological water quality using light microscopy. PPE (personal protection equipment), such as, lab coats, safety glasses and protective gloves were provided in the lab.

Table 6: Computer Science and Software Engineering

Name of Activity	Description
Game Development	The main objective of this activity on computer game creation is to foster innovation, algorithmic thinking, and creativity in the fields of Computer Science and Software Engineering. Specific goals include developing application design skills and cultivating algorithmic and analytical thinking to solve complex problems, all integral to the game creation process. Participants are grouped into teams and work collaboratively to develop a single spaceship game using Unity software.
How to build Metaverse using Mixed Reality	This online session provides an in-depth introduction to the metaverse and its fundamental concepts, including immersion, virtual reality (VR), and augmented reality (AR). Delivered in a lecture format, the one-hour session explains the theoretical foundations of these technologies and their applications. Practical examples from ongoing research are shared to illustrate real-world implementations and advancements. Due to the virtual nature of the session, no hands-on demonstrations or direct student engagement are included. The presentation offers attendees a clear understanding of the metaverse, inspiring curiosity about its potential impact in various fields.
Scratch Coding	This in person session involves building a version of Atari breakout using a simple programming language called scratch. The activity facilitators demonstrate a small piece of code on the projector and the participants replicate that along with adding creative elements of their own. The participants also use math concepts like the cartésien coordinate plane and angles to code the bouncing of the ball in the game.

Table 7: Biomedical Engineering

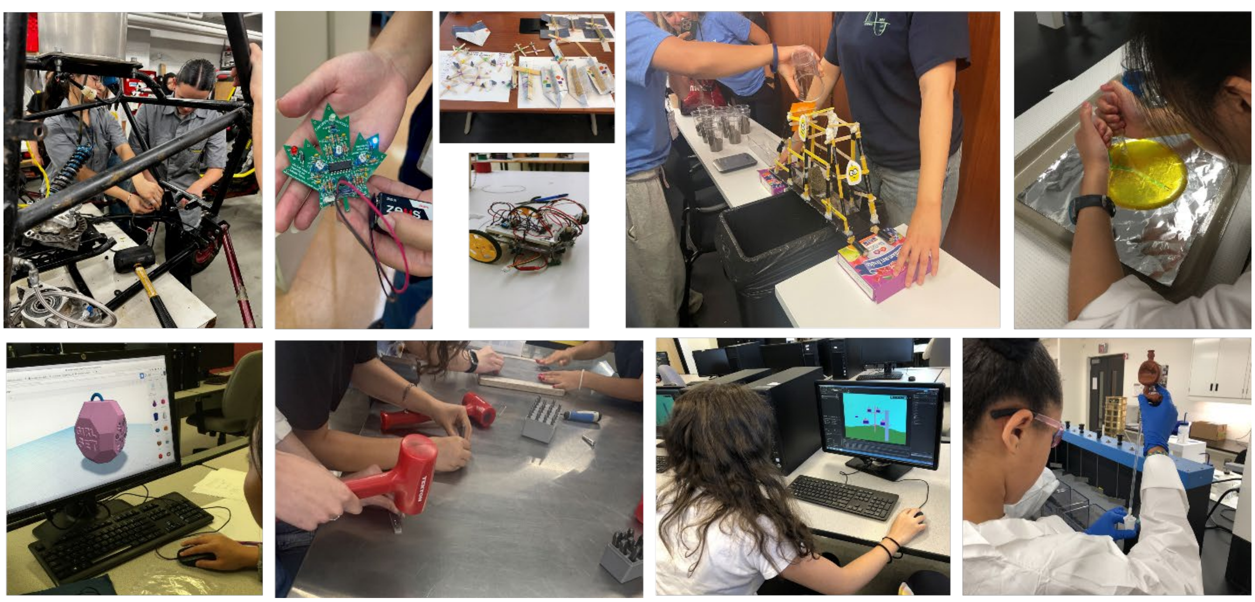
Name of Activity	Description
How to train your surgeon using VR	Attendees experience two interactive virtual reality (VR) demonstrations showcasing cutting-edge research projects. In the Medical VR Training Study, participants practice inserting a virtual catheter into a virtual arm using a 3D visual guidance system developed by the research team. In the VR Wire-loop Game, attendees improve their eye-hand coordination by navigating a loop along a virtual serpentine wire, aided by an adaptive algorithm that adjusts object speed to reduce errors. Every participant gets the opportunity to try both demos, switching between them midway through the session. The presentation highlights the transformative role of VR in medical training, addressing skill gaps and illustrating how VR can offer innovative solutions, supported by examples from the showcased research projects.

Table 8: Chemical and Material Engineering

Name of Activity	Description
Smart Paper for Detection of Water Contamination	In this activity, a Smart Paper (lab-on-paper) is demonstrated to the students for detecting water hardness in a dip-and-read manner. The paper is pipetted with functional materials that specifically react with calcium and magnesium in water. Upon insertion of the paper device into the water, the water is wicked into the microfluidic channels, causing a color change in the device corresponding to the concentration of magnesium and calcium. This demonstration introduces the concepts of microfluidics, lab-on-a-chip, and colorimetric sensors to the students.
Biosensors from lab to everyday life	This activity introduces students to the principles and applications of chemosensors and biosensors through real-world examples and engaging hands-on activities. Participants learn how sensors play a crucial role in daily life, with relatable examples like glucose test strips and COVID-19 rapid tests. The

	activities progress in complexity, starting with using turmeric as a natural pH sensor, followed by detecting salinity with gold nanoparticle tablets, which introduces concepts of nanotechnology. Advanced topics include microfluidics and lab-on-a-chip technologies, where students detect glucose and nitrite with paper-based sensors and design their own microfluidic devices using simple materials. The session concludes with a creative contest to design a biosensor, fostering teamwork and innovation, while inspiring participants to explore cutting-edge technologies in science and engineering.
Making a potato battery and catalyzing elephant toothpaste	The Elephant Toothpaste experiment provides an engaging demonstration of catalysis in chemical reactions, capturing participants' attention with a dramatic foam eruption. In this hands-on activity, hydrogen peroxide decomposes rapidly into water and oxygen with the help of yeast, which contains the enzyme catalase that acts as a biological catalyst. The addition of dish soap traps the oxygen gas released, creating a large foam cascade resembling an oversized toothpaste tube. This experiment introduces students to the concept of catalysts—substances that accelerate reactions without being consumed—and highlights the role of biological catalysts like catalase. It also provides a foundation for understanding the broader applications of catalysis in fields such as energy, health, and environmental sustainability.
A glimpse into the world of Engineering Materials	This session introduces participants to the fundamentals of materials engineering, focusing on the different families of engineering materials and their unique properties. The session provides an overview of metals, polymers, ceramics, and composites, highlighting their distinct characteristics and applications in the real world. Through engaging discussions and hands-on activities, the participants learn how material selection plays a crucial role in engineering design, from construction to electronics. The session also emphasizes the importance of understanding material properties such as strength, flexibility, and conductivity, and how these qualities influence the performance and durability of products. By the end of the session, students gain a broader understanding of how materials shape the world around them and their significance in various engineering fields.

Figure 1: Photographs of hands-on GirlSET activities



One unique aspect of GirlSET is the inclusion of non-technical sessions alongside the in-lab activities described above. During the Women in Engineering Leadership Sessions, participants had the opportunity to hear about the speakers' journeys in STEM careers and ask questions or seek advice. Table 9 shows the description of two such activities.

Table 9: Women in Engineering Leadership Sessions

Name of Activity	Description
Does Engineering Have a Gender?	This session aims to explore the role of women in engineering and address the gender norms and stereotypes that influence their career progression. Participants are encouraged to draw and imagine a female scientist, helping to initiate discussions on the importance of confronting gender biases from an early age. The session introduces Kanter's tokenism theory and female leadership stereotypes, such as the mother, seductress, pet, and iron maiden, explaining how these roles are often imposed on women in male-dominated environments. The session also covers key concepts in the reward system of science, including authorship, inventorship, and citations, while highlighting systemic issues like the leaky pipeline, sticky floor, and glass ceiling. Through discussions and practical recommendations, the session emphasizes the importance of fairness in science and technology evaluation, offering strategies to overcome barriers to women's advancement in STEM fields.
Panel Discussion: Women in Engineering	The Women in Engineering (WIE) panel at the GirlSET summer camp focuses on inspiring young girls to pursue STEM fields by highlighting the importance of gender diversity and equality in engineering. WIE share their mission and the significant role that women play in advancing the engineering industry. The panel discussion is followed by an interactive activity where participants are presented with real-life scenarios faced by women in academia and the professional world. The girls work in groups to discuss how they would handle challenges related to discrimination and discomfort, emphasizing the importance of speaking up. The session concludes with valuable lessons on resilience, advocacy, and the importance of a supportive, inclusive environment for women in STEM.

5 – Insights and Lessons Learned

The GirlSET summer camp not only provides the students with the opportunity to see themselves in a STEM environment, but also helps them build the necessary skills such as teamwork, critical thinking, and logical problem solving. Additionally, the participants develop lifelong friendships and networks that can support their academic and professional journeys. During the panel discussions, the students highlight the importance of female-led hands-on activities, and mentoring sessions, which significantly enhance their interest in STEM fields. The two-week time frame was particularly effective, striking a balance between depth and engagement.

Engineering is mostly about hands-on experimentation and design. One key takeaway is the preference for the in-person format, which allows for social interactions alongside immersive exposure to STEM environments compared to the online version. Furthermore, dividing participants into two in-person sections based on difficulty levels proved beneficial, as tailored activities enhance both interest and engagement. This approach ensures that the program meets participants' diverse needs and fosters a more inclusive learning environment.

6 – Roadmap for Replication and Broader Implications

Implementing a program like GirlSET requires systematic planning, collaboration, and strategic use of resources. Below, we provide a roadmap as a guidance for replicating a similar program:

Secure Faculty and Institutional Support: Start by generating interest among faculty members. We recommend initiating discussions during department meetings, where the majority of faculty members are usually present. In addition to this, securing institutional support is also crucial. Advocating for the program's alignment with institutional goals, such as increasing diversity in STEM, can help gain administrative backing.

Foster Collaboration Among Stakeholders: Establish a collaborative environment that includes faculty, university staff, and students who would be working as activity facilitators and monitors. Engage lab staff, student organizations and other campus groups to assist in providing logistical support. Collaboration among these diverse stakeholders is essential to create a cohesive and successful program.

Secure Funding and Allocate Resources: During its early years, GirlSET was funded by the Gina Cody School of Engineering and summer@concordia. In 2024, the program secured some external funding from the industry partners. Activity facilitators' and monitors' salaries were covered by institutional funding. We recommend leveraging in-kind contributions such as lab-space and materials to minimize costs and ensure program sustainability.

Design the Program According to Institutional Needs: Before designing the program, it is important to conduct an in-depth needs analysis to understand your institution's strengths and available resources. Based on our experience, we recommend prioritizing hands-on activities with active learning strategies over lecture-based methods. In addition, consider separating participants into multiple sections based on grade levels and tailoring the activities to their level of understanding.

Manage Logistics Effectively: Develop a robust registration process to manage participants and ensure trackability. Charging a nominal fee can promote commitment and reduce dropouts. Early planning is critical for securing lab space, classrooms, and other necessary resources.

Involve Industry and Community Partners: Promote your program within the campus community and engage industry and community partners. Highlight the program's role in increasing female representation in STEM. Collaborating with industry professionals can provide participants with networking opportunities, mentorship sessions, and exposure to real-world applications. Industry partnerships can also serve as a vital source of funding and resources.

Evaluate Impact and Refine Your Program: Use participant feedback to continually refine and improve the program. Align the program's goals with broader institutional objectives, such as increasing female enrollment in STEM majors. Additionally, demonstrate how the program contributes to diversity and inclusivity initiatives. Consider aligning with regional or national initiatives, such as Canada's 30/30 goal, to amplify the program's impact and advocate for systemic change in STEM fields.

7- Conclusions and Future Work

The GirlSET program stands as a testament to the transformative power of targeted STEM initiatives in breaking down gender barriers and inspiring the next generation of female engineers and technologists. By addressing the systemic challenges that discourage young women from pursuing STEM careers, GirlSET not only equips participants with technical skills but also fosters critical thinking, teamwork, and resilience—qualities essential for success in any field. Over the years, the program has demonstrated the profound impact of mentorship, hands-on activities, and female role models in shaping participants' perceptions of engineering and technology. One of the key lessons learned from GirlSET is the importance of providing a supportive and inclusive environment that encourages young women to envision themselves as future leaders in STEM. The program's emphasis on diverse activities, ranging from robotics and biomedical engineering to leadership sessions and panel discussions, has showcased the multifaceted nature of STEM fields. This approach helps participants see the relevance of engineering in addressing real-world problems, inspiring them to become innovators and change-makers.

The success of GirlSET underscores the need for sustained investment in similar initiatives. Universities, industries, and policymakers must collaborate to ensure that programs like this are widely implemented and accessible to underrepresented groups. By prioritizing diversity and inclusion in STEM education, we can create a more equitable and innovative workforce capable of tackling the challenges of the 21st century. Looking ahead, the lessons from GirlSET offer a roadmap for expanding the reach and impact of STEM outreach programs. Future efforts should focus on scaling such initiatives nationally and internationally, leveraging partnerships with government agencies, industries, and non-profits. By doing so, we can amplify their impact and inspire a global movement toward gender equity in STEM.

In conclusion, GirlSET is not merely a summer camp—it is a platform for transformation, empowerment, and innovation. As more institutions embrace the challenge of addressing gender disparities in STEM, we move closer to a future where talent and passion, not gender, determine one's opportunities and achievements in engineering and technology.

In future work, we plan to expand on our current findings by incorporating both qualitative and quantitative data collected from program participants. Specifically, we have begun gathering survey data to assess how the program influences participants' perceptions of STEM careers and their feelings about being women in STEM fields. We aim to analyze this data in detail and publish the results in a subsequent paper. This will allow us to better understand the impact of the program and further refine our approach to engaging young girls in engineering.

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References

[1] GUS Canada. Breaking Barriers: Women in STEM. [Online]. Available: https://guscanada.com/breaking-barriers-women-in-stem/

[2] Engineers Canda, National Membership, 2023. Engineers Canada. [Online]. Available: https:// 2023 National Membership Information | Engineers Canada

[3] Engineers Canada. 30 by 30. [Online]. Available: https://engineerscanada.ca/diversity/women-in-engineering/30-by-30

[4] National Research Council. (2009, October). Engineering in K-12 Education: Understanding the Status and Improving the Prospects. The National Academies Press. https://doi.org/10.17226/12635

[5] The White House. Educate to Innovate. [Online]. Available: https://obamawhitehouse.archives.gov/issues/education/k-12/educate-innovate

[6] The White House. Mentoring Our Future Generation of STEM Professionals. [Online]. Available: https://obamawhitehouse.archives.gov/blog/2011/03/30/mentoring-our-future-generation-stem-professionals

[7] Harvey Mudd College. (2012, Sep 17). HMC and Piazza Launch First-Online Community Mentorship Program to Support STEM Women. [Online]. Available: https://www.hmc.edu/about/2012/09/17/hmc-and- piazza-launch-first-online-community-mentorship-program-to-support-stem-women/

[8] Richards, L., Hallock, A., & Schnittka, C. (2007). Getting Them Early: Teaching Engineering Design in Middle Schools. International Journal of Engineering Education, 23, 874-883.

[9] T. R. Rhoads, S. E. Walden, and B. A. Winter, "Sooner Elementary Engineering and Science—a model for after-school science clubs based on university and K-5 partnership," Journal of STEM Education and Research, vol. 5, no. 3, pp. 47-52, Jan. 31, 2005.

[10] M. Levine, N. Serio, B. Radaram, S. Chaudhuri, and W. Talbert, "Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls," J. Chem. Educ., vol. 92, pp. 1639-1644, 2015, doi: 10.1021/ed500945g.

[11] Black Girls Code. [Online]. Available: https://www.wearebgc.org/

[12] STEM Village. How It Works. [Online]. Available: https://www.stemvillage.com/how-it-works

[13] Engineering for Kids. About Us. [Online]. Available: https://www.engineeringforkids.com/about/

[14] Technovation Montreal. Organisation. [Online]. Available: https://www.technovationmontreal.com/organisation

[15] Ontario Network of Women in Engineering (ONWiE). Go Code Girl. [Online]. Available: https://www.onwie.ca/programs/go-code-girl/