

Women in Engineering: Inspiring school students to pursue the "E" in STEM

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CONTEXT

The lack of women representation in Engineering has been a widely recognized problem on a global scale for decades and has been attributed to factors such as societal stereotyping, unwelcoming educational environment and students' STEM self-efficacy. In 2019 the Faculty of Engineering at University of Auckland funded a long-term strategic project to address this inequity and one of the initiatives we developed through this project is the annual Women in Engineering (WiE) Holiday Camp for women high school students.

PURPOSE

Our research aims to examine how to motivate women aged 16-18 in New Zealand to pursue engineering as a career path. This paper addresses two main questions from our overall research study: How do students respond to the WiE Holiday Camp activities? How do these activities motivate women to pursue Engineering?

APPROACH

We take a phenomenological approach to address our research questions, using Ahmed's (2006) theory of orientation to guide our investigation of the camp participants' responses and motivations.

Applying findings from a 2022 pilot study, we use a combination of quantitative and qualitative analysis methods to capture each participant's journey during and after the WiE Holiday Camp and aim to identify common themes or turning points across the group that could be effective intervention stages.

OUTCOMES

From our survey and interview results, we have found that half of all participants acknowledged benefits from attending the camp, including increased knowledge of Engineering and the development of their social network within the faculty's educational environment, as well as recognising their eligibility to pursue Engineering if they desire.

SUMMARY

The WiE Holiday Camp serves to encourage students to consider Engineering as a viable pathway after high school graduation by enhancing their understanding and comfort with Engineering, boosting their confidence in their ability to pursue it, offering potential support networks, and presenting role models who demonstrate the success and impact of women engineers.

KEYWORDS

Outreach, schools, Engineering, women

Introduction

The lack of women representation in Engineering has been a widely recognised problem on a global scale for decades and has been attributed to factors such as societal stereotyping, unwelcoming environments and students' STEM self-efficacy (Madara and Nemango, 2016; Cadaret et al., 2017; García-Holgado et al., 2019, 2020; Makarova et al., 2019; Powell et al., 2012; Verdugo-Castro et al., 2019). In 2019 the Faculty of Engineering at University of Auckland (UoA) funded a long-term strategic project to address this inequity. One of the initiatives we developed is an annual holiday camp for young women high school students, the Women in Engineering (WiE) Holiday Camp.

This initiative is aimed at Year 11 women students who have been identified by their teachers as interested in STEM subjects, creative, problem solvers, team players and leaders - students they think would make great engineers but who are not already strongly considering engineering. The program began with a pilot camp in 2020, but was halted due to COVID restrictions until restarting again in 2022. Students attend a three day, daytime camp with a range of hands-on activities overseen by undergraduates, postgraduates and staff from our faculty.

Engineering holiday camps are an immersive experience that aim to encourage students to consider Engineering as a viable career pathway by enhancing their understanding and comfort with engineering, boosting their confidence in their ability to pursue it, offering potential support networks, and presenting role models that demonstrate the success and impact of female engineers. In this paper we report on student responses from the 2023 WiE Holiday Camp, and discuss how these relate to the larger project goals.

There are similar programmes in universities across Australasia and globally, e.g. the STEM x Holiday Workshops (UTS, Australia), WiE Can (University of Canterbury, NZ), STEM Camp for Girls (University of Wollongong, Australia), YoWIE (UNSW, Australia) and Discover Engineer Summer Camp (Toronto Metropolitan University) (Roberts, 2024; UNSW Canberra, 2024; UTS, n.d.; University of Wollongong Australia, 2021; WiE Can, n.d; Madara and Namango, 2016). Our reasons for providing the WiE Holiday Camp are based on the results from these other institutions, and reports that emphasised continued efforts to offer young women engineering experiences across the globe, such as the 2022 report provided for Engineers Australia (Romani, 2022), the 2019 report for the Engineering Australia Taskforce (Corrigan & Aikens, 2019), the Extraordinary Women Engineers Final Report (Kell Robotics, 2005) from Canada, and ongoing feedback from outreach activities in our own faculty. It is clear that very few of these initiatives can provide a measure of their long-lasting impact, conduct longitudinal analysis of their programs or receive any peer-reviewed attention, and we intend address this gap with our overall research study.

Purpose

Existing studies in New Zealand predominantly focus on exploring career-influencing factors from the perspectives of undergraduate STEM students, as well as junior and senior high school students who are still forming their STEM identity in the classroom (Turnbull et al., 2020; Fox-Turnbull et al. 2023; Mann & Walshaw, 2019). However, there is limited research from the viewpoint of senior high school students in New Zealand who are already interested and eligible to study engineering but may end up studying something else.

Our overall research aims to examine how to motivate self-identifying women aged 16-18 in New Zealand to pursue engineering as a higher education path, and investigate the factors that lead these students to either choose engineering or shift their interest from engineering towards other fields. The initial findings will provide insight to support our future research and assist in implementing strategies to improve inclusiveness and diversity, as well as retention, in the Faculty of Engineering. In this paper, we focus on the impact of the WiE Holiday Camp as a form of support that motivates students considering studying engineering. We intend to move beyond the traditional attendee evaluation measures of enjoyment and information transfer to address

two main questions: How do individual students respond to the activities provided? How could these activities motivate young women to pursue engineering?

Approach

The larger longitudinal study that will run from 2023-2026 has several parts and the main aim is to track the cohort of WiE Holiday Camp attendees through their remaining school years and the year following their high school graduation. These students come from a range of geographical and socio-economic backgrounds. For this conference paper, we present data from two main sources:

- In 2023, we conducted pre-attendance (43 responses) and post-attendance surveys (33 responses) before and after the camp. This approach was chosen to capture immediate responses to their experience, and provide an indication of what, if anything, may have changed their minds about engineering.
- In 2024, we conducted one round of questionnaires (14 responses) and 7 one-on-one interviews with 16-year-old students from the 2023 WiE Holiday Camp. This round of questions and interviews provide a chance to gather more in-depth details around their individual experiences following the camp, and identify key moments or factors that steer them along a particular path.

Ethics approval for this study was granted by the University of Auckland in 2023, reference number UAHPEC26646. The questions we use were developed from our own internal pilot surveys and focus groups and the feedback gained from previous years' outreach initiatives.

We apply Ahmed's (2006) theory of orientation to explore how camp activities influence students' orientation towards engineering, because in our context, we believe that it matters how people end up where they do. Ahmed suggests that individuals are directed more towards certain paths than others, indicating the paths they should follow or where they encounter more challenges. This direction is influenced by four key factors: lived experience, the intentionality of consciousness, the significance of nearness or immediate accessibility, and the impact of repeated habitual actions on shaping both bodies and environments (Ahmed, 2006, p.2). Lived experience delineates what individuals can or cannot do, while the "intentionality of consciousness" explores what lies beyond surface appearances. "Significance of nearness" refers to available support systems, and "the role of repeated and habitual actions in shaping bodies and worlds" underscores the background shaping current behaviours and familiarity. The concept of "lived experience" acknowledges that an individual's perception of reality is shaped by their perspective and the particular circumstances they have experienced. For instance, individuals may develop an understanding of the pathways accepted or rejected by their social circle. This understanding influences their perception of suitable academic paths both during university and after graduation, guiding their educational decisions within a specific context. This orientation forms their lived experience, encompassing emotions, sensations, and insights. This concept is applied to our work in the "Adding Lived Experience" section, where we hypothesise that if positive engineer-related experiences are part of an individual's life, they may choose this path that would have seemed more challenging previously.

We analyse students' responses from pre- and post-attendance surveys, follow-up questionnaires, and interviews focusing on these four factors. We have replaced the real names of our participants with pseudonyms to maintain confidentiality.

Outcomes

Summary of the WiE Holiday Camp in 2023

The WiE Holiday Camp 2023 had 54 high school students, mainly from Auckland but also a few from other regions around New Zealand (all attendees organised their own transport and accommodation for the duration).

The program each year is generally consistent, featuring a half-day campus tour showcasing various applications of Mechanical Engineering, such as Formula SAE (Society of Automotive Engineers), aerodynamics, and materials testing. Other hands-on activities in the 3-day program include 1-2 hour-long workshops such as designing and building structures, 3D printing, city planning for disaster mitigation, robot programming, water filtering, and ambulance simulations. Additionally, there is a student panel to discuss questions and interests of participants related to studying and working in engineering. These activities are mainly led by women staff and university students, but all genders are included in the delivery. The camp closes with a presentation of certificates, mingling and refreshments with accompanying family members.

Adding Lived Experience

Half the participants of the 2023 Holiday Camp acknowledged benefits from attending the camp according to the post-attendance survey. These included increased knowledge of engineering and the development of their social network within the faculty's educational environment, as well as recognising their eligibility to pursue engineering if they desire. This acknowledgment is reflected in the insights shared by Zoe during a follow-up one-on-one interview:

When my dean offered information about the camp to all of us, that's when I first heard about it and thought, maybe this is something I might enjoy. After attending the holiday camp, I really enjoyed it. Probably after the camp, I started thinking seriously about pursuing this in the future. I think engineering is probably my top choice. (Zoe, WiE Holiday Camp 2023)

All participants of the 2023 WiE Holiday Camp post-attendance survey expressed engagement with all activities. Their preferences for these activities varied.

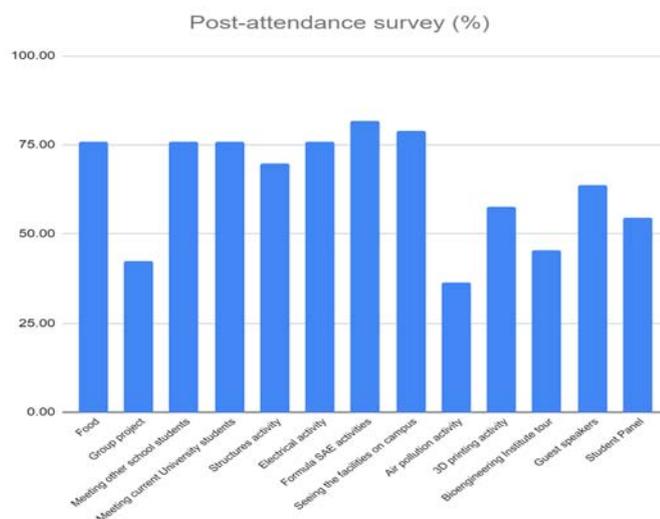


Figure 1: Participant Preferences for Activities at the 2023 Holiday Camp.

Figure 1 shows the varying levels of participant engagement across different activities of the camp. The most attractive aspects for most camp participants are Formula SAE activities (82%), and electrical activity (76%). More than half of the participants found engagement with 3D Printing (58%), while fewer than half expressed interest in air pollution activity (36%) and the Bioengineering Institute tour (45%). A significant number of participants expressed excitement about activities related to the visibility of women, including engaging with guest speakers (64%), current women university students (76%), other women high school students (76%), and a student panel consisting entirely of women (55%). This underscores that having women in roles as facilitators, lecturers and participants at the camp contributes to the comfort and enjoyment of participants.

Participants indicated that they were drawn to particular activities because they align with their passions, help them approach problems logically, help them realise the importance of communication, and offer practical solutions for social issues. Additionally, these activities evoke positive emotions such as enjoyment and mental stimulation. As a result, some students overcame their hesitancy and felt more motivated to study engineering.

I liked the holiday camp. It was awesome. By the end, I understood what engineering is now. (Madison, WiE Holiday Camp 2023)

Madison's use of the word "awesome" and Zoe's expressions "really enjoyed" suggest that both had a highly positive lived experience with the camp activities, leaving them with fond memories and a sense of comfort upon reflection. This feeling was reinforced by gaining deeper knowledge about engineering, indicating they learned more than they previously knew. Their statements imply a memorable experience associated with pleasure.

With respect to the "intentionality of consciousness," individuals' intentions and conscious awareness, influenced by beliefs and sociocultural factors, determine their pathway choices. This concept entails contemplating what lies beyond or is available within these influencing factors. Camp participants noted that influencers like school teachers and parents recommended engineering as a viable pathway. Teachers introduced students to the camp and parents provided consent and funded transportation and accommodation. During the camp, students gained insights into engineering and identified women as guides, facilitators, leaders and participants. This experience helped students understand that engineering is a valid career choice for women, as many women pursue it. Therefore, the firsthand experiences of camp participants like Madison and Zoe can shape their future "intentionality of consciousness."

"The significance of nearness" pertains to immediate and tangible support systems that provide individuals with a sense of comfort, validation, and understanding. Such systems are evident in initiatives including holiday camps aimed at motivating young women in engineering. They serve to enhance their comfort and confidence in considering engineering as a viable university pathway. It is important to continue to provide opportunities to engage after this experience, as regarding "the role of repeated and habitual actions in shaping bodies and worlds." The frequency of repeating actions and words influences individuals' behaviours and choices, particularly in the context of engineering, as illustrated by Aurora, a camp participant.

My science teacher really liked engineering and often talked about it. Then she showed us a poster about going to Auckland. I really enjoyed the holiday camp; it reinforced my belief that engineering would be a career path I would enjoy. (Aurora, WiE Holiday Camp 2023)

Aurora decided to attend the camp after being inspired by her science teacher who frequently shared their passion for engineering, which became a regular topic of conversation. This habit of discussing engineering with passion conveyed a positive message to Aurora and motivated her. Aurora's attendance at the camp was an intentional decision influenced by her teacher's repeated encouragement and enjoyment, rather than a spontaneous one. Aurora's phrase "really enjoyed" to describe her memories of the camp suggests she had a positive lived experience in a favourable environment, which reinforced her belief that engineering is her chosen career path.

Through consistent involvement in engineering-related activities, participants could develop habitual actions that shape broader social structures, institutions, and cultural practices, particularly in fostering the belief that they can have fun and be successful in engineering. The absence of "repeated and habitual actions in shaping bodies and worlds" may diminish participants' motivation to pursue engineering as a career path, particularly when their passions and other regular interactions orientate them toward considering alternatives outside of engineering.

The holiday camp actually did make me reconsider, a little bit. Ultimately, I decided that I would probably prefer to pursue environmental science. However, the holiday camp helped me realise that there is a space for women in engineering, and also many women working in various types of engineering. (Aria, WiE Holiday Camp 2023)

Aria had a positive experience with engineering and learned about the visibility of women in the field through examples provided during the camp. While she appreciated this information, her positive experience was not strong enough to direct her towards engineering at this stage, as her intentionality of consciousness reminded her that engineering does not align with her passion for the environment. She believes environmental science is a better fit. In this case, she may lack the lived experience of engineering as it relates to environmental studies. This information is useful when reviewing the messaging accompanying the activities we deliver for prospective students.

The cases of Aurora and Aria reinforce that holiday camps are just one step in their self-directed process of discovery. However, to motivate Madison and Zoe to pursue engineering as a career, activities that enrich their hands-on experience and align with their passions are needed to strengthen their intentional focus. These activities can be viewed as enhancing "the significance of nearness" and the frequency of engagement in these activities can serve as "repeated and habitual actions" that may guide students towards engineering.

Generating Positive Emotions

Enhanced 'nearness' and habitual actions as described above are also closely tied to emotions that propel us either "toward" (with positive emotions) or "away" (with negative emotions) from such objects (2006, p.2). The positive feelings are directed toward an object framed as a source of pleasure or enjoyment. Ahmed suggests that positive emotions orient a person to move toward an object and embrace its approach. In the holiday camp, the positive emotions students experienced from engaging in various activities helped orient them toward engineering as a potential career path as indicated in their post-attendance survey responses. Therefore, we propose that women exhibit more interest in engineering when experiencing positive emotions like joy, curiosity, and happiness. Conversely, negative emotions may lead them to be drawn to other activities.

I learned so much about how interconnected the different specialisations in engineering are, and how they can collaborate together. I think civil or structural engineering could possibly be really fun. (Camila, the WiE Holiday Camp 2023)

Camila experiences positive emotions at the camp upon discovering a connection between engineering and her strengths in physics and calculation. These feelings shape her lived experience and affirm that she can develop her strengths through engineering. Engaging in activities related to designing and structure building excites her, enabling her to enhance her logical thinking. These positive feelings steer Camila towards civil engineering, potentially influencing her to pursue it as her career path. Like Camila, Gianna had transformative emotions that prompted her to reconsider her career path.

I learned that engineering encompasses various fields that interest many people, not just a single area. For the past two years, I've been focused on architecture, but this camp has made me consider other paths, such as mechanical engineering. I found mechanical engineering to be super interesting and hope to join the Formula SAE group when I attend university. (Gianna, WiE Holiday Camp 2023)

Gianna gained a new understanding of the interconnectedness between engineering and other fields and expressed excitement about the racing car and the Formula SAE group's presentation. This newfound understanding can be seen as her initial "lived experience." Her aspiration to join the Formula SAE group signals a shift from her interest in architecture over the past two years toward mechanical engineering as her career path. We can support her desire to participate in the Formula SAE group by providing further opportunities and related information that enhances her confidence in choosing engineering, thus driving her confidence and ambition to pursue mechanical engineering more decisively. Camila and Gianna successfully connected their passions with an area of engineering, whereas Aria did not have a similar experience. Aria's case suggests that positive emotions alone are insufficient to steer her towards engineering. While she gained confidence and was excited to see the visibility of women in this male-dominated field,

these positive feelings only prompted her to reconsider between engineering and environmental science, and affirm that her current passion for the environment outweighs her interest in engineering.

Influencing Participants' Career Decisions

Ahmed (2006) suggests a correlation between a person's orientation and their proximity to an object. A person is oriented toward what they believe they can reach, a belief shaped by their lived experiences. In the holiday camp, respondents in the pre- and post-attendance surveys were asked to choose one of three orientations regarding engineering as a pathway: 1) definitely considering engineering, 2) still contemplating engineering, and 3) not considering engineering. The choices that participants made may be viewed as reflections of their lived experiences at the camp.

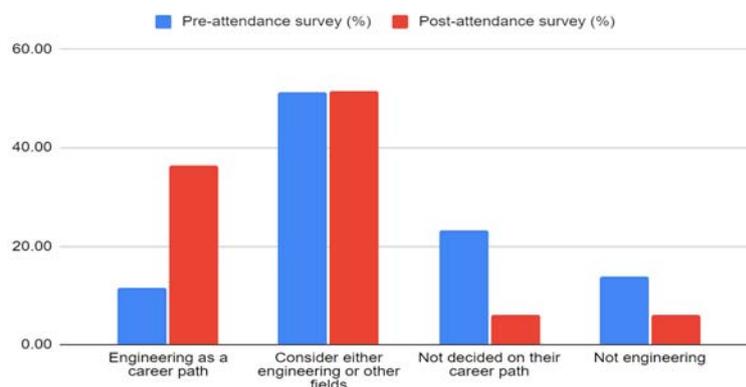


Figure 2: Potential Impact of the 2023 WiE Holiday Camp on Participants' Career Decisions.

Figure 2 illustrates that the percentage of participants considering engineering as their career path increased threefold in the post-attendance survey (36%), compared to the pre-attendance survey (12%). The combined percentage of participants considering either engineering or other fields stayed about the same at 51% - 52%. Conversely, the percentage of participants undecided about their career path decreased dramatically in the post-attendance survey (6%), down from 23% in the pre-attendance survey. Similarly, those considering fields other than engineering decreased by more than half, from 14% to 6%. Only two participants still indicated they would not pursue engineering.

The surveys showed a clear shift in the number of students considering engineering as a career path before and after the camp, suggesting that respondents gained more lived experience with engineering. This indicates the potential positive impact of the 2023 WiE Holiday Camp on participants' career decisions. It would be useful for us to know if this remains fixed, or if there is scope for them to keep an open mind, and our wider research study aims to address this question in the future.

I learned a lot about the work of engineers in the industry and their daily activities. I also realised that engineering may not be the right career for me after considering the various types of engineering and the corresponding career paths. (Riley, WiE Holiday Camp 2023)

Riley gained insight into the professional lives of engineers, leading her to realise that engineering may not align with her career preferences. Either her experience in the camp has now oriented her away from engineering, or it was not enough to change her previously intended career path. Our future research will aim to clarify this distinction, and try to discover what, if anything, may be enough to support students like Riley into engineering, or equally important, accept that this camp provides the opportunity for uncertain students to make more informed career decisions.

Discussion

The results shared from the 2023 Camp demonstrate how certain aspects of Ahmed's theory of orientation are applied in the context of women participating in engineering activities, and so far show an overall positive response to the experiences which addresses the first of our two research questions. We propose that their enjoyment could be the positive indicator that might motivate them to consider engineering as they engage in follow-up activities related to the field. These activities would serve as "repeated and habitual actions," providing them with additional new lived experiences that may foster intentional focus on engineering and develop a stronger passion for it.

Romanis (2022) reported that 86% of women agree that the hands-on activities are important for encouraging further interest in engineering, yet only about 20% of women surveyed had been on a school excursion related to engineering. In light of our second research question, we see that these events can motivate students to consider engineering as a viable career path after high school by improving their understanding and comfort with the field, boosting their confidence in pursuing it, providing a welcoming environment and support networks to continue to tap into, and presenting relatable women engineers as facilitators and lecturers (UNSW Canberra, 2024).

The Extraordinary Women Engineer Project report (Corrigan and Aikens, 2019) outlines strategic recommendations for increasing the number of women pursuing engineering, including creating opportunities, materials and messages to redefine engineering and shift how it is portrayed to them. The WIE Holiday Camp is one of our key initiatives to implement such recommendations, by incorporating key factors that can motivate young women to consider engineering – hands on activities, role models, increased self-efficacy, (Corrigan and Aikens, 2016).

Summary

The WiE Holiday Camp increases participants' exposure to engineering, and we aim to be able to determine whether it has an impact on their career decisions through our longitudinal study. This long-term information is difficult to find in relation to other similar camps in Australasia and the world, probably due to time and budget constraints, as well as ethics considerations.

The theoretical framework we use shows that while the camp can initially orient women towards engineering, to motivate participants to pursue engineering as a career needs subsequent tailored activities that enhance their hands-on experience in enjoyable and inspiring aspects of engineering. This paper acknowledges the wider context of this issue, with modifying the elements of our programme being one contribution to improvement.

We will use further feedback from surveys and interviews to modify certain aspects of future outreach initiatives, aiming to better emphasise the relevance and value of engineering careers to society, increase women engineers' participation in subsequent camps, and promote diversity and inclusivity across various aspects of engineering. We intend our research to provide a framework for understanding how and what to address in an individual's interactions with us to achieve these aims.

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