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Empowering Engineering Female Students to Improve Retention and Progression: A Program Evaluation Study Completed with Bibliometric Analysis

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ABSTRACT

Increasing the retention rate of female students in Science, Technology, Engineering, and Mathematics (STEM) fields has always been challenging in many institutions. Engineering is among the male-dominated fields in both academia and the workplace. In Malaysia, recent statistics indicate that the number of women choosing engineering as a degree is still not encouraging. This paper focuses on the design, implementation, and evaluation of the programs aimed at empowering female students in engineering, where it discusses the methodologies used, the effectiveness of the programs, and the impact on students' perceptions and attitudes toward engineering. Several retention programs that target female engineering students were employed, such as providing a peer-supportive environment, establishing a society of women engineers in university, organizing cooperative events and activities, and exposing them to successful female role models. The effectiveness of the programs was evaluated using a survey administered to female undergraduate students at Taylor's University, Malaysia as part of a one-year project titled "EWE: Empowering Engineering Female Students to Improve Retention and Progression", funded by Engineering Information Foundation (EiF). By using thematic coding and statistical tests, the survey aimed to investigate the motives behind female students' decisions to pursue engineering as a degree and assess Self-efficacy and Sustained Interest in Engineering as a result of the empowerment programs. The programs implemented here can be adapted by other universities, especially in Malaysia aiming to provide opportunities and success rates for female engineers.

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1. INTRODUCTION

In Malaysia, recent statistics indicate that the number of women choosing engineering as a degree is still not encouraging. Statistics data show that there is a slow increase in the percentage of women in the Science, Technology, Engineering, and Mathematics (STEM) fields (https://www.freemalaysiatoday.com/category/highlight/2024/03/05/door-still-shut-for-women-in-selected-sectors; retrieved on March 2024). In fact, STEM is one of the important fields in recent life (Tipmontiane & Williams, 2022; Shidiq *et al*., 2021; Fitriani *et al*., 2024; Susilawati *et al*., 2023).

In the early 1960s, women engineers made up only 1% of engineers and by the 2000s, it had increased to 11% (INTI, 2022). In 2020, the Universiti Kuala Lumpur (UniKL) was responsible for 10% of the total of 245,494 students enrolling in the engineering field of studies. The enrolment included a significant number of female students despite engineering sectors being predominantly male-centered (https://www.thesundaily.my/supplement/unikl-mfi-empowers-women-in-engineering-technology-AG9329406; retrieved on March 2024). However, the number of female students in engineering programs is only 40%. Furthermore, in 2015, women comprised more than 50% of students across all STEM-related courses, except Engineering (https://ibe-infocus.org/articles/malaysia-women-stem/; retrieved on March 2024). However, despite that universities try to introduce a variety of engineering program measures to attract more students including women, the number of female students in the science stream in Malaysia remains low (https://doi.org/10.1109/ICEED.2018.8626959; retrieved on March 2024) resulting in a lower number of registered females in engineering courses. The women's workforce participation rate has increased from 44.5% in 1982 to 49.5% in 2012. Specifically, for the engineering occupation in Malaysia, professional women engineers accounted for 761 in 2019, whereas the rest was 9,166 for men, as shown in **Figure 1**. According to the Board of Engineers Malaysia, in 2019, women represented about 7% of professional engineers. The percentage of registered women as graduate engineers has grown from 25% in 2016 to 29% in 2019 (https://alltogether.swe.org/2021/09/different-or-more-of-the-same-malaysian-women-in-engineering-and-technology-fields/; retrieved on March 2024). This creates issues in the gender gap, and many research regarding gender has been well-documented (Badr & Abdul-Hassan, 2022; Francis *et al*., 2023; Mulyahati & Rasiban, 2021; Boriongan & Abdulmalic, 2023; Pranathi & Kamraju, 2024; Situngkir *et al*., 2024; Fagbemi, 2023).

The gender gap in workforce participation has been found. In fact, workforce do not have correlation to this matter (Stephen & Festus, 2022). It has been known that the gender gap narrowed significantly between 1982 and 2017, from 40.8% to 25.4% (Yee Lim, 2019). In 2008, the female workforce participation rate in Malaysia was relatively lower at 45.7% as compared to neighboring countries such as Singapore (60.2%), Thailand (70.0%), and Indonesia (51.8%) (https://doi.org/10.1016/S0197-2456(02)00197-6; retrieved on March 2024). Several factors contribute to this decline, for example, the fact that most women choose to work part-time (Yee Lim, 2019) due to family responsibilities and thus fail to get promoted or reach higher positions in the workforce. Due to this fact, women are deemed to be less committed to engineering as compared to men (https://doi.org/10.1109/ICEED.2018.8626959; retrieved on March 2024). Moreover, several challenges can prevent females from choosing Engineering as a career, such as stereotypes and discrimination. STEM fields are male-dominated, for example, in social science, women outnumber men, providing females with more role models as compared to Engineering

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(https://www.ni.com/en-my/perspectives/inspiring-malaysian-girls-to-pursue-engineering.html, retrieved on March 2024).

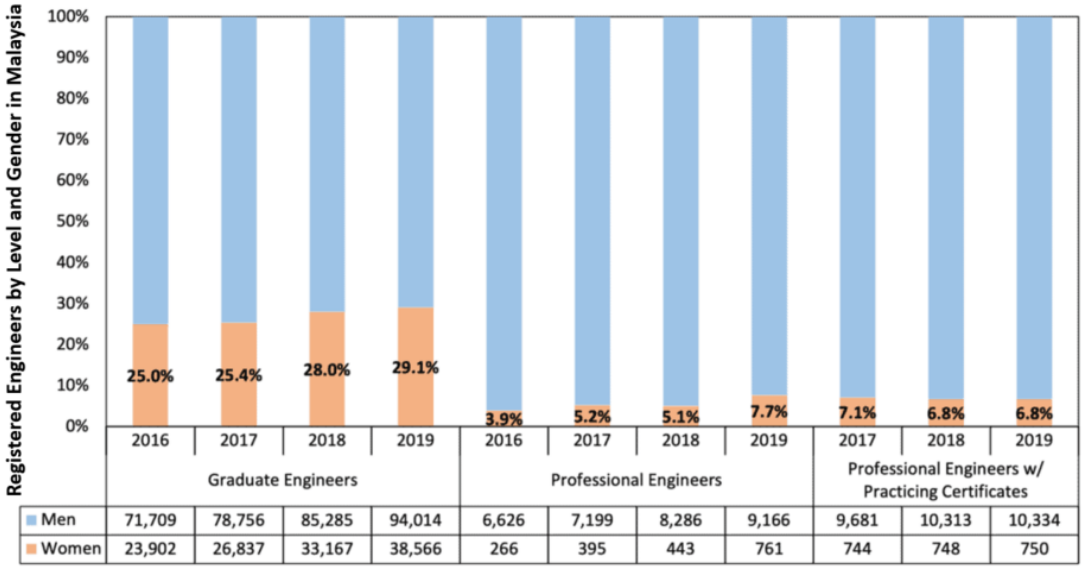

Figure 1. Registered Engineers by level and gender in Malaysia for the period (2016-2019). Source: Board of Engineers Malaysia, 2019.

Globally, the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. One of these goals is Gender Equality which aims at achieving gender equality and empowering all women and girls (United Nations, Goal 5, Gender Equality, year 2022). It is reported that, in 2019, women accounted for 39% of total employment, but 45% of global employment loss. This data indicates the importance of providing effective solutions to increase women's employment and improve the retention rate of undergraduate women. Engineering is not an exemption.

This gender gap leads to loss for both, organizations, and women. Therefore, it is crucial to overcome these misconceptions and expose women to engineering opportunities. Overall, Malaysia has shown an increasing commitment to closing this gap as it plans to become a developed nation. The Malaysian government labeled the STEM field as the main catalyst for the transformation of the country by 2020. According to the Malaysia Education Blueprint (MEB) (2013-2025), strengthening STEM is a key element (https://ibe-infocus.org/articles/malaysia-women-stem/; retrieved on March 2024). Therefore, addressing this gap can contribute significantly to this plan.

The primary objective of the research is to offer an all-encompassing analysis of the structure, execution, and assessment of the initiatives within the undertaking entitled "EWE: Empowering Engineering Female Students to Enhance Retention and Progression" at Taylor's University. This endeavour is funded by the Engineering Information Foundation (EiF). Our contribution in this study can be summarized as follows:

(i) An overview of retention programs targeted for female engineering students in university.
(ii) Summarize the best practices and key lessons learned from implementing the empowerment programs.
(iii) Provide recommendations for universities and organizations aiming to create similar initiatives to support female students in STEM fields.
(iv) Investigating the motives behind female students' decisions to pursue engineering as a degree.

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(v) Assessing Self-efficacy and Sustained Interest in Engineering as a result of the empowerment programs.

2. LITERATURE REVIEW

2.1. Deployment of the Intervention Programs

Improving the retention rate of women in Engineering could result in many benefits for organizations and women. If universities can produce female graduates with high qualifications in the STEM field, the country's economy could be greatly improved, encouraging higher participation of women in the labor force.

The following sections provide a description of the retention programs available for female engineering students at Taylor's University, Malaysia. The combination of such programs can yield an effective outcome of encouraging female students to succeed in their degree. The program components are depicted in **Figure 2**. The following subsections provide a brief synopsis of the five-retention program and describe how they were implemented, the resources, and requirements.

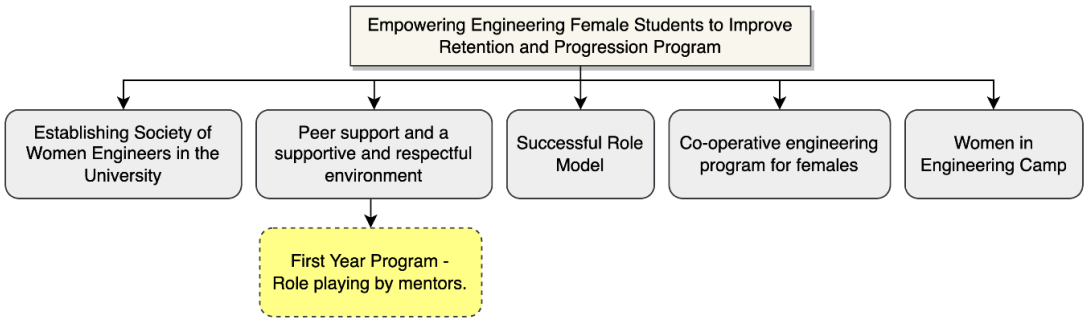

Figure 2. EWE program components.

2.2. Peer Support and A Respectful Environment

Peer support in assisting female engineering students when they are having trouble with engineering coursework. Peer describes or explains at the student level any learning issues. Having this in the early semester proved to set standards of behaviour for the whole course which will continue in the workplace. Female mentors will be provided by pairing upper-class and graduate students with first-year female students.

2.3. First Year Program - Mentor's Role

Final year program explores discrimination, racism, and prejudice, aiming to foster critical understanding, empathy, and proactive strategies for addressing these issues in our society. To show students how their action can influence their learning environment, teach female students not to tolerate mistreatment. This program was delivered through workshops and inviting over new female students to lunch events to make them feel they are not alone in this field. Eventually such sessions allow the students to communicate with each other, making them feel more confident and enhancing their social and communication skills.

2.4. Successful Role Model

The significance of female alumni and female industry professionals within the field of engineering is highly regarded. They will share their experiences and projects. This component involves conducting workshops and inviting successful female engineers to motivate and inspire the students with their success stories. For female engineering students,

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peer friendships and motivations are identified as vital and enhance their confidence level to thrive in progressing and completing their studies.

Having a successful role model can help students pursuing their engineering degree hearing their professional counterparts who are successfully completing their Engineering education and how they are sustaining in their careers as professional engineers among their male counterparts. Role models in this case can be alumni female students that can conduct sessions that include presentations (experience sharing) and interactional opportunities between the speakers and the audience.

2.5. Co-operative Engineering Program for Females

Co-operative engineering program was conducted through a series of sharing and problem-solving sessions among students, academics, and professionals from academia and industry. Inviting internal speakers from the same university can expose the students to broader perspectives on engineering fields. Hearing and gaining encouragement from academics can further boost their confidence and teach them how to engage better in the classroom. This will furnish female's understanding on the field and expected outcome from the students.

2.6. Society of Women Engineers - EWE

Empowered Women Engineers (EWE) is a club established within this program. We targeted 40 female engineering students in Taylor's University (TU), Malaysia, to form an organization consisting of 6 Advisors (grant holders and TU lecturers from different schools such as the School of Engineering, the School of Architecture, Building and Design, and the School of Computer Science), Executive committee (EXCOs - female students) and members. The club allows female students to network with other female students while participating in the activities that are of interest to them. This platform supports relevant initiatives including the sharing of ideas, knowledge, and experiences, with an aim to increase awareness and participation of women in technical and engineering roles and to build capacity for women in engineering. Female engineers who are actively engaged in their profession will share their personal experiences and provide insight into their career trajectories with students. We also collaborated with National (Institute of Engineers Malaysia- women Engineers - IEM) and international organizations (Cross Border Engineering) and their activities and connected female students to pave way for career opportunities and personal development.

The five main objectives of EWE club are: (1) encouragement and motivation to female engineers; (2) Build connections and networking with female engineers; (3) Organize workshops and sharing sessions; (4) Connect female engineers to future careers; and (5) Establish fun and engaging activities for bonding. The TU EWE club was formed in March 2023 and currently has over 50 members. Advisors and EXCOs take the opportunity at each orientation session to advertise the club to new students which gives them an early feeling of belonging and supported. The junior female students are encouraged to enrolment by their senior peers where it provides them with opportunities to reach out to their peers in a collaborative environment.

2.7. Women in Engineering Camp

A 1½ days event titled "WE & Sustainability 2023" for female Engineering students from Public and Private Universities was organized. The invitation was sent out via emails by reaching out to other established clubs at 10 Public Universities and 5 Private Universities with engineering programs in Malaysia. The event was hosted in TU, inviting lecturers, head

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of school and associated professors. In, this event, three competitions were sponsored by EiF and we collaborated with IEM. The camp included three main competitions and challenges for female students including (1) Rafting the Flood (group); (2) Design Challenge (individual); and (3) Biomimicry on the spot design challenge (inter Uni). Additionally, the camp included Biomimicry- Design thinking workshop where professional engineering and architecture speakers were invited.

The major activities in this camp are competitions and motivational workshops as studies reveal that competitive spirit and motivation are important to sustain in the engineering field. Competitions also improve the communication skills, and the interpersonal skills, as well as they promote greater counterfactual thinking, rumination, and emotional reactions. Reese *et al*. (2022) concluded that the least competitive person will strive for victory when it truly matters, but some people maintain a competitive fire even when situational pressures are weak. Tinto's widely accepted retention model posits that students remain enrolled in university to the extent that they experience a sense of academic and social integration within the university community. The motivational camp has been seen as a potential effort in helping students to achieve and enhance these skills. The length of the program had influenced participants' life effectiveness, and it is potential for a longer program to give a greater impact and long-lasting effects rather than a shorter program. Wahid *et al*. (2014) mentioned that students will perform better in mathematics if their mathematics anxiety is low. They proved in their study that mathematic workshops and motivational camps reduced students' anxiety and resulted in better performances.

3. METHOD

This study applied quantitative method to collect and analyse the data. The population included female engineering undergraduates from Taylor's University in Malaysia. The participants were sampled as first-year female students from March Intake 2023, joining the the newly established EWE club as part of the "Empowering Engineering Female Students to Improve Retention and Progression" program, which allows us to evaluate their progress before and after the implementation of the project programs. The following subsections further explain the data collection and survey design.

3.1. Data Collection

A comprehensive survey has been created and distributed to 40 female students in the School of Engineering (SOE) via email, social media communications such as WhatsApp and word of mouth through Engineering lecturers. All four engineering programs offered in Taylor's SOE were included such as Mechanical Engineering, Chemical Engineering, Electrical and Electronic Engineering, and Robotic Design and Development. The survey is solely focusing on students enrolled for the March 2023 academic intake. The questionnaire is distributed online through Google Forms and responses were returned in like manner. The data collection process was divided into two phases (2 questionnaires) to completely understand female student's beliefs, progression, challenges, and feedback. The phases are explained in **Table 1**. The responses were later retrieved and stored in a Microsoft Excel database.

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Table 1. Survey plan.

	Initial Data collection	Final Data collection
Purpose	The first survey serves as a purpose to explore the views of female students currently enrolled in Engineering.	The second survey aims to evaluate the performance of those female students and whether the program managed to empower them to continue and pursue engineering.
Items considered	Understanding of Engineering, views on gender equality in STEM fields (female participation), and the motives of choosing Engineering.	Challenges that female students face in class in Engineering, student's satisfaction, academic performance, long-term interest and self-efficacy in Engineering.
Method	Quantitative Survey through Google Forms.	
Timeframe	March 2023 (before project/ programs implementation)	November 2023 (after project/ programs implementation)

3.2. Survey Design

The questions were designed based on the review of existing literatures and the paper's authors' interest and expertise. Two surveys were created consisting of 32 questions. There were a total of 18 items in the first survey and 23 in the second survey. The questions were mixed of open-ended, option-based. 5 point Likert scale was used to measure the level of importance or agreement to the statements of the survey. The sections consisting of demographic questions were strictly used for statistical purposes such as date of birth, nationality and engineering major. All participants were presented with an introductory paragraphs about the survey explaining the purpose of data collection and to guarantee that their data will be retained and analysed during the project period only.

In the initial survey, two "Understanding (UND)" factors were derived from literature (https://doi.org/10.18260/p.26427; retrieved on March 2024) and (Madara & Namango, 2016). Two "Motives (MOT)" were derived from literature (https://doi.org/10.18260/p.26427; retrieved on March 2024) and finally, three items regarding female engineering "Initiatives (INT)" were derived from literature (https://engineersaustralia. org. au/sites/default/files/women-in-engineering-report-june-2022. Pdf; retrieved on March 2024). While for the final survey, two "Interest (INT)" and five "self-efficacy (SEF)" items were derived from (Andrews et al., 2021). Finally, three "Inclusiveness (INCL)" items with slight modification were derived from (https://doi.org/10.18260/1-2--16809; retrieved on March 2024).

3.3. Survey Analysis

The survey was analysed using Python 3 language with libraries in Juypter Notebook [https://jupyter.org/] such as pandas (for data processing), pingouin (for statistical tests), seaborn (for statistical data visualisation) and matplotlib (for visuals or figures). It is as a powerful tool that can be used to create interactive and shareable documents. For open-ended responses, the data was analysed using a qualitative data coding techniques known as thematic coding which is part of inductive analysis. In this approach, the codes and categories are not predefined, they are extracted as the researchers delve into the data (Bingham, 2023). This process involved looking for commonalities and patterns in the responses and creating a coding scheme based on the recurring themes. Once the responses are organized and categorized in key themes, quantitative analysis was performed such as the frequency and distribution of the derived themes.

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4. RESULTS AND DISCUSSION

This section presents a comprehensive analysis of the data collected through our survey, offering a detailed examination of the key themes, valuable insights into the perceptions, experiences, and opinions of university undergraduate female students in the field of engineering.

4.1. Research Trend in Women in STEM using Bibliometric Analysis

Figure 3 shows the results of current research trends using bibliometrics regarding women in STEM. Data was obtained on March 2024 from Scopus database. Detailed information how to use bibliometric is shown elsewhere (Al Husaeni & Nandiyanto, 2022).

Bibliometric is one of the effective methods for understanding research trend. Several examples are explained in the literature, which explained from various aspects and fields:

(i) Science and Engineering (Ramadhan *et al*., 2022; Shidiq, 2023; Nandiyanto *et al*., 2024; Lizama *et al*., 2024, Al Husaeni *et al*., 2024a; Al Husaeni *et al*., 2024b; Al Husaeni & Nandiyanto, 2022; Al Husaeni, 2022; Alhosani *et al*., 2023; Anwar *et al*., 2023; Hiererra *et al*., 2023; Hirawan *et al*., 2022; Kurniati *et al*., 2022; Laita *et al*., 2024; Lestari *et al*., 2023; Lizama *et al*., 2024; Luckyardi *et al*., 2022; Nandiyanto *et al*., 2023; Nandiyanto & Al Huseni, 2022; Nandiyanti *et al*., 2022; Nandiyanto *et al*., 2024; Nandiyanto *et al*., 2023a; Nandiyanto *et al*., 2023b; Nurrahma *et al*., 2024; Ramadhan *et al*., 2022; Roestamy *et al*., 2023; Ruzmetov & Ibragimov, 2023; Saputra *et al*., 2022; Saputra *et al*., 2023; Shidiq, 2023).

(ii) Science Education (Al Husaeni *et al*., 2024; Al Husaeni & Munir, 2023; Al Husaeni *et al*., 2023; Al Husaeni, 2023; Al Husaeni & Al Husaeni, 2022; Al Husaeni & Nandiyanto, 2023; Ashel *et al*., 2023; Firdaus *et al*., 2023; Hofifah & Nandiyanto, 2024; Marlina *et al*., 2023; Mashudi *et al*., 2023; Rasuman *et al*., 2024; Riandi *et al*., 2022; Zafrullah & Ramadhani, 2024)

(iii) Other Education (Ragadhita & Nandiyanto, 2022; Pramanik & Ramanita, 2023; Al Husaeni *et al*., 2023b; Nursaniah & Nandiyanto, 2023; Al Husaeni & Wahyudin, 2023)

(iv) Religion (Al Husaeni & Al Husaeni, 2022; Chano *et al*., 2023; Chano *et al*., 2024)

Based on analysis in **Figure 3**, research regarding women has increased attention, shown by many publications in this subject, reaching 18,772 documents in Scopus. Many reports have been published (Abulude *et al*, 2022; Effiong & Alya, 2022; Yadav & Jadhav, 2023; Delju & Habibi, 2024; Barge & Jadhav, 2022; Ali & Kamraju, 2023; Alimi & Animashaun, 2023), and detailed information is delivered and explained in the next section.

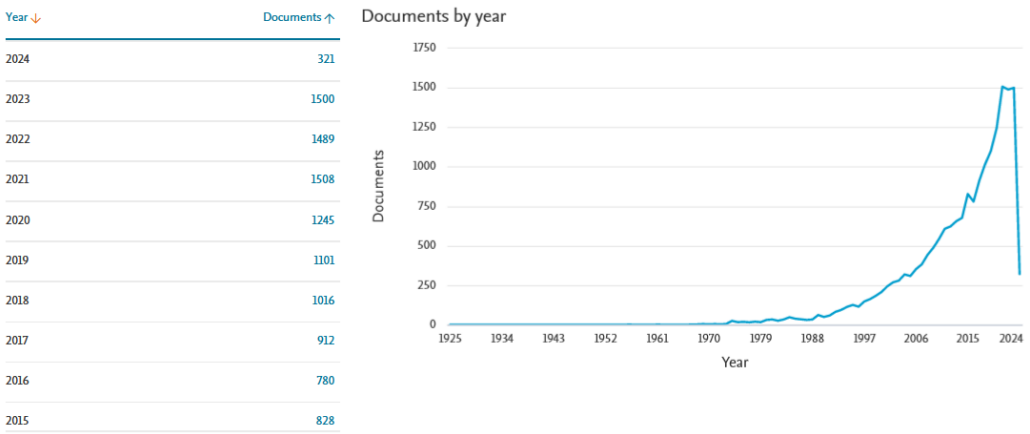

Figure 3. Research trend in women in STEM.

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Figure 4 shows a network visualization of a bibliometric analysis of research on women in STEM. Network visualization shows the connections between terms that are often used in this research. The larger the circle or node in the image, the greater the number of finds of the term with a specified minimum number of occurrences, namely 10 times and 60% of the most relevant terms (Al Husaeni & Nandiyanto, 2022). In this study, 268 items were found which were grouped into 4 clusters. In this case the terms girls, country, initiative, project, stereotype, female, math, difference, effect are terms with a high level of occurrence..

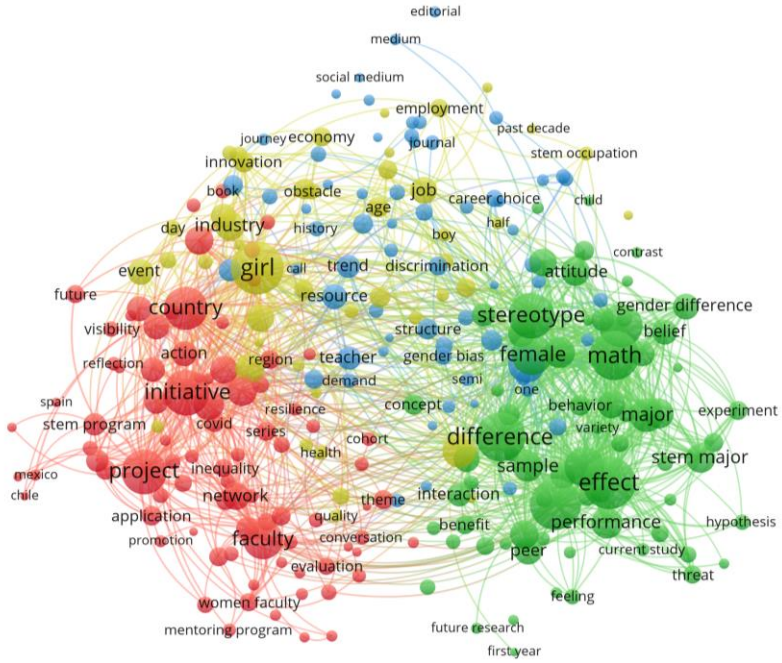

Figure 4. Network visualization of research in women in STEM.

4.2. Participants Profile

The survey involved the participation of female students from four engineering programs, as observed in **Table 2**. Participants were in the age range of 16 to 23 years old. Most of the participants were Malaysian (71.8%), second highest were Chinese (10.3%) and the rest were from Indonesia, Pakistan, south Korea, Tanzania and Maldives. Half of the participants (53.8%) were not first-generation students and nearly half were (41.0%). Most of the students have attended private high school (56.4%) and second highest attended public (35.9%), the third category attended Chinese Independent school (5.1%) and 2.6% were home-schooled.

Table 2. Engineering major.

Major	Count	Percentage
Mechanical Engineering	15	38.5%
Chemical Engineering	14	35.9%
Electrical and Electronics Engineering	9	23.1%
Robotic Design and Development	1	2.6%

4.3. Perception and Understanding of "Engineering"

The survey respondents' perceptions of what engineers do revealed several key themes as summarized in **Table 3**. A significant portion (33%) associated engineers with "Innovation and Improvement," highlighting the recognition of the profession's dynamic and forward-thinking nature. Additionally, 23% emphasized "Problem Solving," underlining the importance of

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analytical skills in the engineering domain. Furthermore, 18% identified engineers with both the "Application of Science and Mathematics" and "Building and Design," showcasing the multifaceted nature of the profession. The presence of these themes signifies a well-rounded understanding of the diverse roles and responsibilities undertaken by engineers in the eyes of the surveyed participants.

In relation to the understanding of Engineering, the participants were asked: When you think about "an engineer", what are the first (two or three) words that comes into your mind? **Figure 5** showcases a word cloud revealing the most frequent associated words.

Table 3. Perception on what engineers do.

Key themes	Count	Percentage
Innovation and Improvement	13	33%
Problem Solving	9	23%
Application of Science and Mathematics	7	18%
Building and Design	7	18%
Miscellaneous	3	8%

Figure 5. Words associated with "Engineer".

These categories reflect the diverse perceptions associated with the term "engineer" ranging from technical skills and innovation to responsibility and problem-solving. The top five (5) words associated with the term are "Innovator", "Problem Solver", "Creativity", "Smart" and "Building". Some responses also include miscellaneous or unique associations such as being too hard or masculine, being more suitable for men, showcasing the varied perspectives people have about the role of an engineer. These findings reflect a positive and multifaceted view of the engineering profession, emphasizing not only technical skills but also creative thinking and a broader societal impact through building-related activities.

Moreover, Salas-Morera *et al*. (2021) findings reveal that while engineering is viewed as a high valued profession by girls, they are still convinced that this is not a suitable profession for women. The authors suggests that this is due to the education barriers in the earlier stages of their educational journey, for example, the lack of understanding of this field in High school could be one of the negative factors preventing women from choosing engineering as a university degree. The survey findings were consistent with the existing literature where although majority of the participants (56%) are from private school, they state that they have not interacted with any engineer or scientist as part of any classroom activities at their former school. These findings imply that more activities should be introduced in schools to enhance student's exposure to engineers. This could be achieved by incorporating more interactive sessions, workshops, or classroom activities involving professionals from engineering and science fields. This could help bridge the gap between students and these professionals, providing valuable insights and inspiration for their educational and career paths.

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4.4. The Motives Behind Pursuing an Engineering Major

The findings in this section were in line with several studies, as revealed by Chou & Chen (2015), where a case study in Southern Taiwan explored the perceptions and motives of 30 female college engineering students, and it was revealed that the main motives for choosing engineering are interest in STEM subjects such as Math and Science, inspired by family experiences as also supported by Hodgkinson *et al*. (2019), for high salary jobs, and to apply sciences.In a separate investigation carried out by Mozahem *et al*. (2019), a survey was conducted involving 30 female engineering students in Lebanon. The findings of this study unveiled the primary motivations behind females opting for this particular domain, including their inquisitiveness to gain further knowledge about the subjects and their desire to push their own boundaries. In this study, around half of the participants (48.6%) were influenced by a particular person or experience to make their decision to pursue engineering, where Parents were identified as the main influence for their degree choice (22.9%), and Teachers were the second highest influence (4.3%). As a result of the performed thematic coding, we identified six main themes that shape the motives behind pursuing an engineering major for female students and are discussed as follows:

(i) ***Theme 1: Interest and Passion for Subjects.*** Most female engineering students perceived that their interest and passion for mathematics and science subjects such as physics and chemistry was the main factor that drove them to choose engineering as a university degree. For example, one student stated, *"Because it is the right option for me. Nothing else would suit me. I also love maths and am good in physics.",* while another student stated*, "I love physics very much and how it can relate to our everyday lives"*.

(ii) ***Theme 2: Career Opportunities and High-Paying Job.*** The second significant factor influencing the decision to pursue engineering is financial prospects and job opportunities. Many female students (17.5%) associated engineering with being a prestigious career choice and a well-paid job. One student stated, *"Good prospects and salaries ;)"*, and another stated, *"I am interested in this subject and I thought it might be a well-paid job"*.

(iii) ***Theme 3: Lack of Clear Direction or Other Options.*** Some participants have conveyed that they chose engineering due to not having other options or simply because they do not have a clear path on their major *"I chose engineering because I had no other option after completing my studies in A levels."*

(iv) ***Theme 4: Application of Knowledge for Societal Benefit.*** Some female students considered engineering to be an applied science that allows them to practically apply academic theories, particularly in product design and development *"I hope to apply my knowledge in sciences and maths towards improving processes or creating products which would benefit the welfare of society."*. In their minds, engineering relates to daily technology use.

(v) ***Theme 5: Interest in Specific Engineering Fields.*** Female students also expressed their diverse range of passion for learning specific and focused fields of engineering, such as physics and medical. *"Interested in the medical field of engineering.",* and *"Wanted to pursue Aerospace Engineering.".*

(vi) ***Theme 6: Influence from Family or Recommendations.*** Some female students conveyed that their family members or relatives were the main reason for their choice of engineering as their major. This is often related to the past experiences of their relatives *"I saw how my cousins built their careers."*, or their parents *"my mother recommended*

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me, and I love DIY.". Therefore, we can conclude that family influence can act as a contributing factor to guiding young females towards engineering majors.

4.5. Barriers

The participants were asked an open-ended question to gather their opinions about the barriers that prevent female students from pursuing engineering. These key themes highlight a range of challenges, from societal attitudes and stereotypes to concerns about safety. The identified barriers have been supported by the literature where it is found that parents have an influence and Perceived Difficulty about females choosing engineering as a major (Mozahem *et al*., 2019). Addressing these barriers is crucial for creating a more inclusive environment and encouraging women to pursue careers in engineering. The top 5 identified barriers are listed below:

(i) ***Stereotypes and Discrimination:*** One of the common barriers that may still persist till today is viewing engineering fields as suitable career or major for men only which leads to discrimination as negative factors *"Lack of support, becoming housewives to take care of kids".* Furthermore, the misconception that girls cannot succeed due to their physical and emotional weakness *"They feel we're too weak to carry heavy tasks"* and *"Society pressure on gender norms"*.

(ii) ***Perceived Difficulty and Emotional Factors:*** On the other hand, female participants mentioned that engineering as a major is perceived to be hard *"The course is too hard.",* or other barriers that are associated with emotions such as being overwhelmed and unable to actively participate *"In my opinion I think most of women are shy when it comes to speaking their minds or airing out their views on something. I can guarantee I'm one of them."*

(iii) ***Lack of Awareness:*** Several students highlighted that the lack of understanding and efforts to promote the fields to young girls is another barrier that should be addressed. *"Lack of awareness, its intimidating in general, from a young age not taught strong STEM skills".* For example, the lack of understanding of this field in High school could be one of the negative factors preventing women from choosing engineering as a university degree. Such responses proved the need for such initiatives, and future projects should be aimed at promoting engineering in schools to empower young students and to change their perception that *"it is a man's field"*.

(iv) ***Male-dominated:*** Many female students mentioned that engineering is perceived as a men's job, mentioning gender inequality and society's belief that girls can't perform as well as boys. One student stating that, *"Insecure job (have seen jobs that specifically recruit males ONLY)"*.

(v) ***Safety Concerns and Working Environment*****:** Some participants have attempted internship as part of their studies, where some female students shared their experience. A student from Electrical and Electronics Engineering major mentioned that it can be uncomfortable working on site as an engineer, stating that, *"Safety reasons; (based on experience from my internship period; there are too many foreign male workers on site, which can be unsafe for a female to walk around alone and it causes inconvenience to the employer and co-worker).*". while the rest shared their thoughts of how the work place can be full of discrimination and requires strength for physical tasks.

4.6. Statistical Tests and Reliability Analysis

In this subsection, we delve into statistical analyses that have been conducted to test the reliability and relationship within our research variables.

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Prior to implementing the deployed programs explained in above, we asked the participants, the female engineering students about the importance of some initiatives related to the proposed programs. Such insights helped us in assessing the willingness of students to participate and utilize these initiatives if there were to be introduced in Taylor's.

Using the survey items discussed in above, a Cronbach's alpha test was performed. Cronbach's alpha assesses the internal consistency of a scale, indicating how well the items within the scale correlate with each other. It is also considered to be a measure of scale reliability (Shrestha, 2021).

The results are depicted in **Table 4**. The Cronbach's alpha value ranges from 0 to 1, where it should be higher of above 0.7 to achieve an acceptable reliability. As can be seen in Table 4, all items achieve acceptable value of 0.73 to 0.90 except TE item, therefore, the responses must be interpreted carefully for this item.

Table 4. Cronbach's alpha test results.

#	Factor	Items	Reliability (Cronbach's Alpha)
1	Initiatives (INIT)	INIT01-7	0.90
2	Interest (INT)	INIT01-4	0.96
3	Self-Efficacy (SEF)	SEF01-5	0.94
4	Teaching (TE)	TE01-6	0.04
5	Inclusiveness (INCL)	INCL01-8	0.73

After performing a descriptive analysis of the mean, median, and standard deviation of the above items, it is found that, in summary, there is a general positive inclination toward the importance of these elements related to engineering initiatives, programs, and events aimed at encouraging girls and women to pursue engineering, with some variations in the perceived importance of specific aspects. It is notable that peer support and a supportive environment (INT05) received particularly high ratings, while the importance of talks from guest speakers (INT03) showed more diverse opinions.

Moreover, Interest and self-efficacy items generally received positive ratings. Teaching items had varied responses, with TE02 having lower satisfaction. Inclusiveness items showed a mix of positive and lower satisfaction, particularly in items related to interruptions, difficulty in active participation, and engaging in conversations.

In **Table 5**, these correlation coefficients suggest positive relationships between TE03 and the interest and attitudes towards engineering. In simpler terms, as the enjoyment of being an active participant in the engineering major (TE03) increases, the likelihood of finding engineering interesting (INT01), enjoying learning engineering (INT02), and having an interest in learning more about engineering (INT03) also tends to increase. The likelihood of positive attitudes and self-efficacy in engineering-related area correlates highly with the enjoyment of being an active participant in class.

Table 5. Correlation matrix of interest and self-efficacy items.

	TE03	SEF05	INT01	INT03
INT01	0.69	x	x	x
INT02	0.61	x	x	x
INT03	0.69	x	x	x
SEF01	0.78	0.82	0.60	0.61
SEF02	0.65	0.78	0.68	0.61
SEF03	0.72	0.82	0.57	0.57
SEF04	0.60	0.82	x	x
SEF05	0.78	x	x	x

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The high positive correlations suggest that individuals who are confident in various aspects of their engineering abilities (SEF01 to SEF04) also tend to be confident in their ability to excel in engineering exams (SEF05). This reinforces the idea that self-efficacy in different areas of engineering is related to overall confidence in performing well in exams.

Students who express a keen interest in learning more about engineering also tend to exhibit higher levels of self-efficacy in grasping engineering concepts. Students who perceive engineering as interesting are more likely to have confidence in understanding engineering concepts both in and outside the classroom, as well as in overcoming setbacks related to their engineering studies.

In **Table 6**, (INCL02 with INCL06 = 0.7354 and INCL08 = 0.6043), this indicates that individuals who report experiencing gender discrimination while taking leadership roles are highly likely to also report being interrupted when they speak in class.

This suggests that individuals who have experienced gender discrimination in leadership roles are also more likely to face challenges when engaging in conversations with their male classmates. This implies that individuals who share common interests or characteristics with their male peers are more likely to feel a sense of connection and relatability with them in the classroom environment., this correlation suggests that the perception of commonalities with male classmates is associated with a higher likelihood of feeling a connection or relatability with them in the academic setting. Moreover, individuals who experience frequent interruptions when speaking in classrooms are highly likely to encounter challenges in engaging in conversations with their male classmates. The robust positive correlation suggests a connection between these two aspects of inclusiveness, indicating that challenges in classroom participation may extend to interpersonal interactions with male peers.

Table 6. Correlation matrix of inclusiveness items.

	INCL02	INCL03	INCL04	INCL05	INCL06	INCL07	INCL08
INCL02	1	0.18	0.26	0.08	0.74	0.41	0.60
INCL03	0.18	1	0.74	0.58	0.08	0.05	-0.13
INCL04	0.26	0.74	1	0.78	0.34	0.33	0.18
INCL05	0.08	0.58	0.78	1	0.15	0.21	0.09
INCL06	0.74	0.08	0.34	0.15	1	0.55	0.84
INCL07	0.41	0.05	0.33	0.21	0.55	1	0.67
INCL08	0.60	-0.13	0.18	0.09	0.84	0.67	1

4.7. Evaluation of the Deployed Programs

This subsection will highlight the feedback received from the female engineering students who have participated in the programs enclosed in above section. The following paragraphs highlights the strengths of such initiatives targeting at supporting and empowering female students in universities with a sprinkle of responses received from participants.

The participants highlighted the key takeaways from the events, several themes were concluded through thematic analysis and coding scheme. Themes such as the importance of networking *"I get the opportunity to networking with the peoples who have worked in the industry and get useful insights from them."*, community and support *"It's nice to see so many women engineers supporting me throughout my journey studying engineering."*, broadening perspectives, gender equality, project management, empowerment, inspiration from guest speakers, and career development. Responses varied, with attendees expressing the significance of building connections, learning from diverse experiences, and gaining insights into industry challenges and opportunities.

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Furthermore, participants shared struggles they faced in engineering and how the events helped overcome these challenges. Key themes included interview skills and finding jobs, career guidance and opportunities, time management, determination *"..Those events provide me insights and like make me more determined to continue pursue engineering degree"*, perseverance, public speaking, personal development, and fitting into the engineering field *"..but the events showed me that female engineers can also make it big in the industry"*. The events were credited with providing knowledge, boosting confidence, and offering solutions to various obstacles, ultimately aiding in personal and professional development.

The participants also highlighted their likes and enjoyment during the events, emphasizing networking, insights from guest speakers, information on engineering societies, competitions, constructive feedback, and the overall atmosphere. Attendees appreciated the opportunity to connect with like-minded individuals, gain diverse perspectives, and receive feedback *"I liked the feedbacks given from the competitions as they were very constructive and enlightened me to work harder and better in the future ."* that motivated them to excel in their pursuits.

Lastly, positive changes resulting from these events were highlighted, including increased confidence *"I think I speak more and ask more compare to previously when I'm joining similar events, like I know what I can ask and what to ask.",* leadership skills, encouragement to pursue engineering careers *"I'm more encouraged to work as an engineer in the future"*, overcoming challenges, enhanced creativity and innovation, and expanded professional networks. The events were recognized for contributing to personal growth, professional development, and a more confident and motivated outlook among participants.

4.8. Recommendation

Considering the results obtained followed by the analysis and discussion in the previous sections, the following points outline the recommendations:

(i) Creating a supportive environment for female engineering students, including peer support and networking events, contributes to personal growth, professional development, and increased confidence and motivation.
(ii) Initiatives aimed at encouraging girls and women to pursue engineering should focus on teaching students not to tolerate mistreatment and to be aware of how their actions can influence their learning environment.
(iii) Inclusiveness in engineering programs should address issues related to interruptions, difficulty in active participation, and engaging in conversations.
(iv) Universities should consider organizing workshops and events to foster communication and confidence among female engineering students.
(v) Universities can adapt the programs implemented in this study to provide opportunities and improve success rates for female engineers, particularly in Malaysia.
(vi) Addressing discrimination, racism, and prejudice in engineering programs is crucial to creating a more inclusive and supportive environment for female students.

5. CONCLUSION

The paper discussed retention programs aimed at empowering female students in engineering. The evaluation of such programs has shown promising results in improving retention and progression rates. Through the establishment of peer-supportive environments, societies of women engineers, cooperative events, and exposure to successful female role models, significant strides have been made in addressing the gender gap in engineering fields.

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The findings of this study underscore the importance of continued efforts to support and empower female students in STEM fields, particularly in male-dominated disciplines like engineering. The strategies and initiatives outlined in this paper serve as a blueprint for other universities, especially in Malaysia, seeking to enhance opportunities and success rates for female engineers.

This study is subject to certain limitations that should be mentioned and considered for future researchers aiming to implement such programs in the university. It is worth to mention that this is a preliminary analysis, mainly due to the relatively small sample size resulting from the limited number of female students in engineering who participated in the events. Therefore, aiming to generalize the findings represented here should be taken with caution, as the scope of representation may not fully cover the various experiences and perspectives within the broader population.

As the programs are expected to persist and evolve through the engineering society, it is anticipated that the reach and impact will expand, attracting a more substantial number of upcoming female students. Future researchers should aim to address this limitation by incorporating a larger and more diverse participant pool, as this will enhance the study's insights, understanding the experiences of female engineering students in different settings and overall support the ongoing efforts to encourage inclusivity and diversity within STEM fields.

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7. AUTHORS' NOTE

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