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Innovating Inclusion: Unveiling the Journey of Women Pursuing Engineering Education in Cameroon

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Abstract

The presence of gender-related challenges within the milieu of engineering education is an undeniable reality. Going beyond borders and cultures, these challenges fade the shadow over the learning journey of female students in the engineering field. These challenges can build barriers and obstruct their goals in the field. The main focus of this study is to analyse the self-recognised challenges and experiences of female students pursuing engineering at the National and Advanced School of Mines and Petroleum Industries (NASMPI). Mixed method research was applied to this study; a questionnaire was addressed to ninety-five female students and graduates who were randomly chosen from the National and Advanced School of Mines and Petroleum Industries. The female students and graduates chosen represented each of the eight engineering departments of the school from each year of a five-year master's program (from levels one to five). According to the study findings, female students faced numerous gender-related challenges in studying at NASMPI. The study has made recommendations in order to limit these challenges and make the engineering milieu comfortable for everyone.

Keywords: key words, Women Students; Self-experience; Gender-related Challenges; STEM Education

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1. Introduction

The science, technology, engineering and mathematics (STEM) field is experiencing a shortage of skilled workers (UNESCO 2022), yet it is experiencing a great improvement in technological development (McGuire et al. 2020). According to (Baruah and Zhang 2021), engineering and technology are prerequisites for any country's economic industrial growth and development. Today's engineering students are trained to help society overcome the evolving world's present and future problems. This calls for an evolution in engineering schools to break the gender stereotype and train skilled workers to face these challenges. Some researchers (Nerad and Miller 1996; Nerad and Miller 1996; Srivastava et al. 2010) have stressed the significance of attracting and maintaining engineering students for the sake of technological developments and to meet the changing needs of the labour market. They have further acknowledged the significance of gender diversity in the engineering field and in engineering education (Madara and Cherotich 2016a). Nevertheless, there are still few women in the engineering environment, and even some who are successful in the milieu are tempted to leave because of their challenges and experiences. This circumstance contributes to the low percentage of women in engineering. According to Madara and Cherotich (2016a), the primary challenges stem from a noteworthy situation in which "engineering and gender stereotypes converge." The gender stereotype argues that women are viewed as less intelligent, less competent and weaker than men, while the engineering stereotype considers engineering as a complicated and male job field. Consequently, this limits the attraction of qualified women to fields that are eager to grow due to the underrepresentation of women in the STEM profession, especially in engineering. Furthermore, gender underrepresentation in the engineering profession and education is exacerbated by other gender-related learning challenges in the engineering milieu. For instance, the engineering field is considered as a male-dominated milieu, which impacts women's aspiration to integrate into the field (Livingstone and Pollock, 2004). Society has also significantly contributed to attributing a "male" image to the engineering field; given that the STEM sector has been socially ascribed to men, women may fear rejection in the field of study and careers (Blackburn 2017; Nosek et al. 2009).

The stubborn and persistent challenges faced by women in STEM are problems that both limit the diversity of the engineering workforce and prevent many women from pursuing technical interests in engineering education or related careers that require an engineering background. Across the globe, there is substantial variation in women's engineering participation, but under-representation remains almost universally consistent (Wilson and

VanAntwerp 2021). For instance, engineering undergraduates are 5% female in Japan, 15% in the United Kingdom, and 25% in India, although the degree of under-representation also varies by country like the United Kingdom, the engineering workforce for example, is less than 10% women, whereas Bulgaria is over 30% and China is 40% female (Singh and Peers 2019). The experiences of the female students pursuing engineering at NASMPI are unknown, which is a source of concern as engineering education is male-dominated at this level. While it is known that admission to Cameroon's public universities is based on marks scored in High School and the cut-off points, it is also possible that there are other factors influencing the choice of engineering and the ability to remain persistent while studying in the male-dominated faculties.

Given the above, the issue involving the challenges and experiences of women in engineering has not yet been exhaustively explored. The presence of women in STEM education is still insufficient to put an end to gender prejudice in the area, which makes the process of women being promoted to and remaining in the engineering field even more difficult. Therefore, it is essential to undertake a salient discussion on the subject to raise solutions that contribute to changing these paradigms. Thus, this study is undertaken to investigate the experiences and challenges of women engineering students, their motivation to study engineering and, subsequently, the possible support that could be given to female engineering students. Therefore, the strategy used in this work is based on self-recognised challenges and experiences of women engineering students and graduates. The investigation results provide critical information about the different challenges and experiences of the women; the study has, therefore, made recommendations to enhance women's studies in the engineering field. This paper is organised into five blocks: an introductory part as the first block, the literature review in the second block, and the third block, which describes the materials and methods. The fourth block presents and discusses the results, respectively. The fifth section contains the conclusions.

2. Literature review

Historically, the engineering milieu has been dominated by males and, consequently, has led to the underrepresentation of women. Canel and Zachmann (1997) point out that science-related institutions, organisations, and professions are not gender-neutral but display persistent male dominance. The underrepresentation of women rises with the level of occupational hierarchy in STEM, with women in the United States and Europe taking over low-ranking posts (Canel and Zachmann 1997). Even though female students score exceptionally well academically in mathematics and sciences, comparatively few women are still studying engineering (Beraud 2003). The literature on women's participation and representation in the STEM environment has disclosed the existence of the "leaky pipeline" (Seymour 2005) through which women often drop out of the STEM field at different levels of their educational and professional journey. This resulting scenario has significantly affected the entry of women into the engineering profession.

Learning technical courses might present gender-related challenges, which are a global phenomenon. A few authors have demonstrated the experiences of women in engineering. For instance, Bertocchi and Bozzano (2019) observed that female students in engineering and technological fields sometimes feel discouraged by their teachers' statements such as: "Women cannot be real engineers; why should you spend your time and energy?". The female students encounter a "learned helplessness" situation due to the discouragement from the lecturers, and the researchers also emphasised some teachers' incapacity to grant opportunities, contributions and participations to both female and male students in engineering and related courses. Likewise, it was mentioned years ago by Melsa, Rajala, and Mohsen (2009) that some teachers do not promote an environment in which both female and male students can participate equally in technological courses.

Additionally, Dworkin et al. (2013) point out that teachers in engineering institutions sometimes look at male students with higher expectations and respect while female students are undervalued. Consequently, female students in this field are sometimes regarded as incapable, thus leading to the dropout of some women from the field. The male students systematically present challenges to female students in engineering courses. They may be intentionally or inadvertently forwarding messages to their female counterparts that they are not invited to contribute to class projects or discussions (Jones et al. 2000). This claim is supported by Dee (2007), adding that female students in engineering and related fields sometimes experience low confidence as their peers consider them to be less competent. Considering they fear being underestimated by their teachers and male counterparts, they abstain from asking and responding to questions. However, some of these challenges have an impact on their learning activities where the female students fear handling machinery and equipment as a result of the fear instilled in them by their teachers and classmates that they are incapable (Beraud 2003).

A few studies try to determine women's motivation to choose engineering. For instance, these researchers,

Kvande (2007), Smith and Dengiz (2010), and Tully and Jacobs (2010), indicate that some female students' choice to pursue engineering studies is directly linked to the strong interest they have in mathematics. According to Tully and Jacobs (2010), women who believe they perform well in mathematics are likelier to pursue engineering studies. This situation is especially noticeable for those who attended single-gender schools. Therefore, a substantial correlation exists between female choice and their interest in mathematics. Moreover, students' mathematics background and experience does not only influence their likelihood of choosing engineering studies or STEM career but also to the entry requirements which is related to a specific level of mathematics or grade (Chipman and Wilson 1985; Richey et al. 2018; Hansen et al. 1995).

According to Beraud (2003), women seem to succeed in a single-gender educational milieu more than in mixed-gender ones. A single-gender educational environment may offer female students a setting where they can progress and go beyond stereotypical professional expectations. Sociocultural scripts, culturally based stereotypes and perceptions of others may sometimes shape what someone holds about their abilities (Hartman 2010). Women feel empowered, competitive and confident in single-gender education, encouraging them to choose engineering as their post-secondary educational path. Furthermore, women pursuing studies at single-gender schools exhibit higher career aspirations than students attending coeducational schools (Watson, Quatman, and Edler 2002). On the other hand, gender roles sometimes prevent students from attempting to excel in non-traditional career paths and having higher educational ambitions; hence, the presence of good role models and supportive network systems to help female students reach their career and academic objectives (Kvande 2007). According to studies, when some female students do not encounter female engineer role models, they believe that they are not up to the standard of these opportunities; consequently, they never give a try to engineering (Tully and Jacobs 2010).

Therefore, emphasising the retention rate of female in engineering could profit both the women and organisations hence they will contribute to the growth of the economy through high participation of women in the labour market. According to Shafiq et al. (2024) and Hardtke et al. (2022) the persistent barrier influencing women in engineering education or career is considering engineering as suitable career for men only which has led to discrimination and underestimation of the women in the field. It also limits chances to women to experience self-concept and social fit (Schmader 2023). Sometimes this stereotype extends to the household where children's perception about engineering is shaped through ongoing interactions with their parents. As they grow, they nurture the idea that engineering is a major male field. Parents interactions with their male children on STEM is different compare to the female children. They sometimes unconsciously encourage and provide more scientific and mathematical information or explanations to their male than their female children (Moridnejad, Fox-Turnbull, and Docherty 2022). Also, when a female is good at mathematics or science subject some teachers and others in society may link this to high efforts while for a male they connect it to his high logical thinking ability. This negative evaluation of the girls' performance can have a negative impact on their beliefs about abilities.

Young children at the age of 7 years believe in their mathematic capacities. As the grow around the age of 10 years, the girls begin to doubt on their abilities in mathematics. However, at the adolescent stage the boys admit that the girls are also good as them in science. This belief of the male start changing with time when due to social awareness that prevents them from adapting to their opinions (Moridnejad, Fox-Turnbull, and Docherty 2022). The stereotypic image of STEM as a male has been shrinking over time, nevertheless it still exists even more among the boys and becomes deeper in adults than in younger children (Schmader 2023). Therefore, as stated by (Mozahem et al. 2019) women environment including family, friends and culture may have an impact on the choice of their career path. This displays how stereotypical belief and perspectives can flow from one generation to the other. However, women who have an unweaving passion with strong support system consisting of family, friends, educators and role models may choose and persist to remain in a male dominated field. Support from families and stakeholders will obviously enhance the women academic performance potential (Melak and Singh 2021). An engineering environment with limited women expertise may miss out crucial contributions and new strategies of approaching problems that require a blend of talent, therefore, possessing a diverse workforce in engineering related field may contribute to economic growth and development (Moridnejad, Fox-Turnbull, and Docherty 2022). Attracting more women to STEM education or career is nurturing in them a sense of belonging by empowering them to get involve in the rapid technological advancement of the world (Kong et al. 2020).

Wang and Degol (2013) address the motivation for gender-related STEM career choices from a psychological perspective. However, from a psychological standpoint, Yazilitas et al. (2013) focus on micro-level and macro-level patterns linked to the uneven representation of students of both genders in STEM. Conversely, a deep literature review on how friends and familiar social groups influence high school students' decisions to pursue

studies in mathematics and science (Gottfried et al. 2017). Additionally, Mozahem et al. (2019) examine female engineering students' past and current experiences and their decision to persistently remain in the engineering field. The findings show that women engineers still face social, professional and educational challenges. Their choices are questioned by society (relatives and friends), and discrimination and harassment persist as a problem in the STEM field.

Moreover, Dias Canedo et al. (2019) examined the obstacles women encounter when working on software development projects. The authors set out to identify strategies to encourage women to participate in software development projects. The main finding of this study shows that women are underrepresented in software development projects, making-up less than 10% of the total developers. Their workplace, reflecting male dominant environment and gender bias, could be the leading causes of this underrepresentation. Schmitt (2021) also analysed how crucial the help of others could be in combating the male-dominated work culture in engineering. The findings reveal that social support is needed to facilitate the adaptation and journey of female students in the engineering field. The recent research conducted by (García-Peñalvo et al. 2022) brings out an interesting perspective and highly pertinent insights into the challenges, good practices and experiences of women in STEM fields in higher education. The author emphasised that progress must be made in solving the challenges women face in the STEM field in Latin America. It is evident from the reviewed literature that research related to female challenges and experience in the engineering field in developing countries such as Cameroon has not yet been explored. This is a gap in the literature and reaffirms the innovative contribution of the present study.

3. Material and Methods

This article accounts for a comprehensive gender-related study conducted within the context of the esteemed National and Advanced School of Mines and Petroleum Industries (NASMPI) institution. This study employed a comprehensive approach, implicating both qualitative and quantitative methods. The primary tools for data collection were a designed questionnaire and interview sessions. Explicitly targeting women students and graduates, the questionnaire investigated information about their parents, focusing on aspects such as their educational level and their parents' careers. The questions also explored the motivations behind their choice to pursue engineering. Beyond all these, the survey dug into the students' experiences and challenges within male-dominated fields, seeking insights to address these challenges and enhance the overall environment for women in engineering. Through this approach, the study aimed to provide a detailed understanding of the factors influencing female students in engineering.

3.1 Area of Study

The study was conducted at the National and Advanced School of Mines and Petroleum Industries (NASMPI) in Cameroon. It was set up by the University of Maroua, one of the universities in northern Cameroon, after the recommendation of the head of state. It started in 2014 with 250 students who succeeded in the competitive entrance examination. Given the enormous demands relating to the exploitation of major mining and energy production sites that are currently operational in Cameroon, the creation of the National and Advanced School of Mines and Petroleum Industries in the University of Maroua is an adequate response made by public authorities to the need for crucial and qualified professional training. It currently has eight departments, namely: Mines & Quarries (MQ), Petroleum & Gas Exploration (PGE), Refining & Petro-chemistry (RPC), Industrial Safety, Quality & Environment (SQE), Petroleum & Gas Economics & Management (PGE), Petroleum & Gas Production (PGP), Mechanical & Electrical Engineer and Petroleum & Gas Storage & Transportation ("The University of Maroua" 2024).

3.2 Ethical consideration

All the participants were asked to participate in the research voluntarily. The purposes of the research were clearly explained to the participants. Therefore, to secure the privacy and confidentiality of the participants, all collected data were anonymised, maintaining their rights and autonomy throughout the research process.

3.3 Sample

A sample size of ninety-five (95) students and graduates were randomly chosen at the National and Advanced School of Mines and Petroleum Industries. The participants chosen represented each of the eight engineering departments of NASMIP from each year of a five-year master's program (from levels 1 to 5).

and the customer side (i.e. the external environment) as well as between the ZH and the human resources division (i.e. the internal environment). As the whole process will repeat for every production period, a database

has to be integrated into each of the holons for efficient information storage and retrieval.

3.4 Procedure

Female engineering students and graduates were given a questionnaire to capture their experiences and challenges within the engineering field. Before distributing the questionnaire, it was imperative to clearly articulate the purpose of the research to the participants, ensure confidentiality, and emphasise voluntary participation. The questionnaire and interview guide addressed the following aspects: factors influencing decisions to choose the engineering field, parents' educational background and occupations, comfort levels and interest within the field, treatment of female students, possible challenges they encountered and remedies to enhance the engineering milieu. Subsequently, the data gathered from the questionnaire underwent detailed analysis. Graphical representations with the help of Excel were utilised to facilitate comparison across diverse participant perspectives, enabling thorough data analysis. However, data obtained from open-ended interview was analysed using a thematic approach which enables the researcher to identify patterns and create themes to illustrate the meaning participants attach to the different aspects of the situation under study (Braun, Clarke, and Weate 2016). Therefore, this involved reading and re-reeading the data to find a way to navigate through. The data segments that were relevant was coded and worked out to find differences and similiarities. This led to the identification of themes and patterns, then organised in connection with the specific research questions.

4. Results and Discussion

A comprehensive questionnaire and interview data analysis was conducted after receiving responses from the women students and graduates of NASMIP. Approximately 96% of the questions reap responses, with only a few potentially left unanswered, likely owing to inadequate or insufficient data. The subsequent phase involved a thorough examination and evaluation of the questions. This evaluation aimed to uncover insights and extract meaningful conclusions from the rich dataset generated by the responses.

4.1 Findings related to the first research aim

The first research objective aimed to identify the factors that influence the participation of women in engineering at the National and Advanced School of Mines and Petroleum Industries (NASMPI) in Cameroon. Based on the interview and questionnaire data, the factors obtained have been grouped into three categories: personal, historical, and sociocultural.

4.1.1. Personal factors

Passion:

Our results showed that 42.1% of these young women are motivated by an intense passion and love for the engineering world. Such a group of individuals have self-confidence, the skill and knowledge to do the work, and self-identify as STEM professionals like "This is who I am". Some respondents noted that they are very self-motivated to face any challenges on their education path, as they are looking and focusing on the results of their dreams. They probably also have a bigger chance to succeed in their career, which they love (Madara and Cherotich 2016b). In this light, a student declared as follows:

"*…I have always loved anything related to technical since secondary school. This passion of becoming an engineer animates me, and I am confident I will".*

Their intrinsic motivation and interests sustain the choice of some women in engineering. As a result, as long as these aspirational students continue to pursue their passion and excitement of becoming engineers, they will serve as outstanding role models to future female generations and contribute to creating a more innovative and inclusive engineering field. Let their example and experience lead women to an inclusive engineering milieu where all are welcomed with open arms and talent is recognised without boundaries.

Performance and ability:

On the other hand, a few participants (15.79%) said their entry into engineering was because of their incredible performance in science subjects in high school. Their performance augmented their self-confidence and encouraged them to take the engineering path. Research has demonstrated that high school students who excel better in mathematics are more likely to study engineering as a university major (Kvande 2007; Smith and Dengiz 2010). High math and science test scores are prerequisites for engineering courses, which these ladies may quickly meet.

I knew this field demanded a solid foundation in science subjects. I chose this field because I excel at science

subjects, especially mathematics. My high school performance instilled the confidence to get into this fantastic field, and I do not regret choosing engineering.

Honour and prestige:

The prestigious nature of engineering was cited by about 10.53% of the participants as significantly impacting their decision to pursue education in the discipline. They highlighted how respectable engineering is as a profession, especially for women, since they are limited in number compared to their male counterparts. According to these respondents, engineering is generally regarded as a male-dominated environment, and being a female engineer, you gain tremendous respect and recognition. These students' decision to pursue engineering was partly influenced by the idea that it is a high-status profession. Their motivation came from the belief that engineering would improve their personal and professional standing. A graduate declares:

''Engineering is respected because people know that only serious individuals can come in; that is the main reason that led me to choose engineering. In my quarter, when I walk around, people do not call me by name but ''engineer", and they respect me because I am a lady. I like that."

4.1.2. Historical factors

Role model:

About 20% of these women were motivated by role models in their surroundings. They pointed out that interaction with these role models (female engineers) greatly influenced their choice and fed the passion they presently have for engineering. One of the main ways that motivation influences career choices is by inspiring individuals to explore their role models positively. When motivated by a positive role model, one's vision is to reflect the particular person and go beyond their achievements. Additionally, respondents highlighted the implication of media in shaping their aspirations. Television programs showcasing influential and successful female engineers sparked interest in engineering at a young age. Remarkable women's accomplishments in the engineering field were often cited as motivating. Their inspiring stories frequently show how future female engineers may manage obstacles in the field

4.1.3. Sociocultural factors

Parents' educational background and support:

The survey reports showed that the parents' educational background influenced these students' choice of engineering in higher education. Concerning the father's level of education, I found that the majority of the latter, 43.15 %, had a university degree, while most of the mothers had attended tertiary (38.94%) and secondary (30.52%) education. A few students (16.83 %) did not provide an answer to this question.

Figure 2 and Figure 3 summarise the students' parents' level of education.

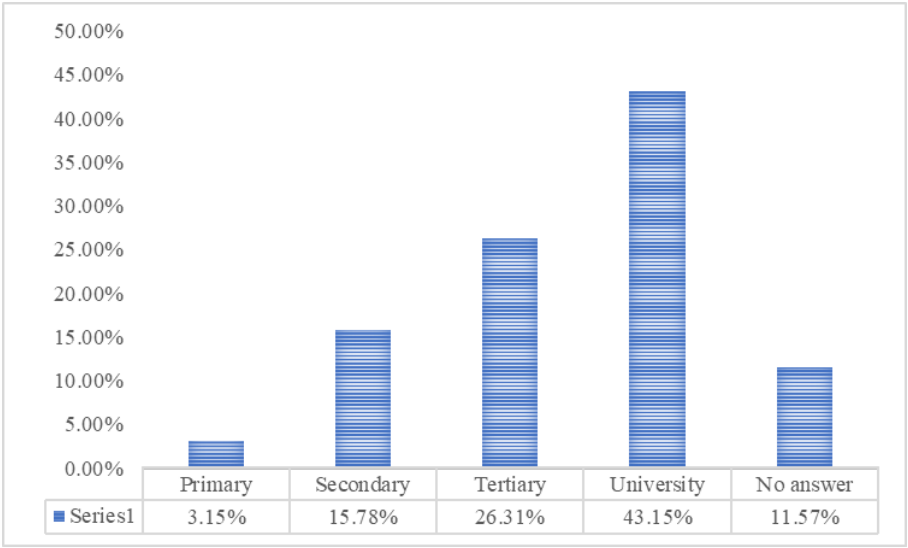

Figure 2: Fathers' level of education

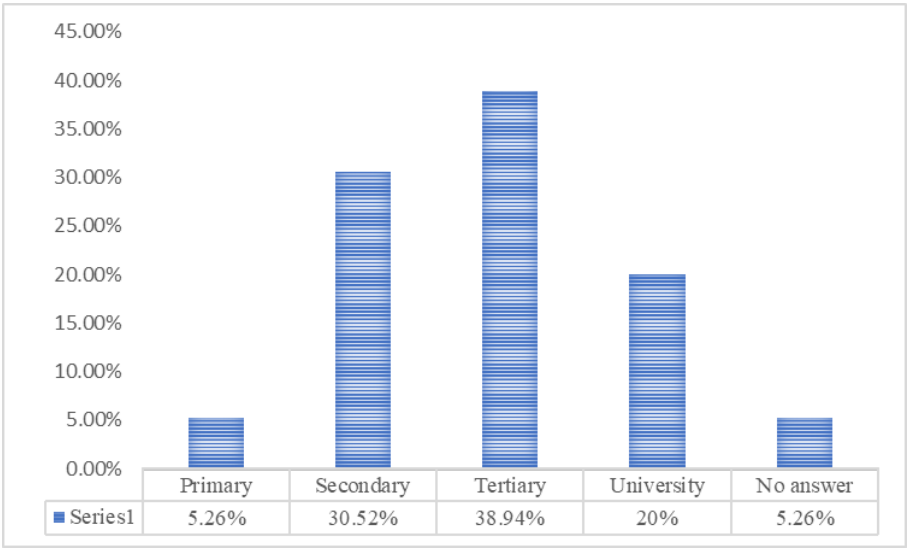

Figure 3: Mothers' level of education

From the histograms in

Figure 2, we can see that the father's level of education shows that the highest number, 43.15 %, were university graduates, while 26.31% completed tertiary education. For the mothers, as shown in Figure 3, tertiary education had the highest percentage at 38.94 %, followed by 30.52% for secondary education. Overall, the tertiary level of education was prevalent, giving the highest total of 65.25% for fathers and mothers, very closely followed by the university level of education at 63.15%.

In addition to other factors, a majority of the interviewees (58.95%) highlighted their parents' level of education as one of the sources of encouragement in choosing the engineering field. They credited their parents for showing them how vital engineering is and instilling confidence in them as girls. These interviewees also expressed gratitude towards their parents for being a support system, especially in a milieu where girls' education is not that valued (in some communities). Some parents' educational background and life experience have made them value education and empower their daughters not to be influenced by some traditional gender norms. Therefore, the study concludes that parent's education level influences female students' career choices in engineering. Most of the students in this study have parents who had completed tertiary and university education. These parents likely have good knowledge of engineering and, therefore, could be able to encourage their children effectively. This finding is also supported by Ardies et al. (2015), who state that mothers with higher education degrees significantly impact students' technological career ambitions. Some students confirm this influence during interview sessions, with the following statement reflecting their perspectives:

"I come from a community where female education is still not valued; if not for my parents' level of education, I couldn't have been part of this family (engineering). Education opened their mind to the world and made them see things better. My parents also inspired me to choose this field, and I'm so grateful to have them".

Parents' occupations:

It was analysed whether the parents' profession could influence girls' career choices. Figure 4 summarises the students' responses regarding their parents' professions. From the students' reports, only (9.47%) had their fathers employed in engineering-related fields, while (5.26%) had their mothers engaged in engineering or related fields. Most females in engineering were expected to pursue engineering because their parents were in the field; however, these percentages show the opposite.

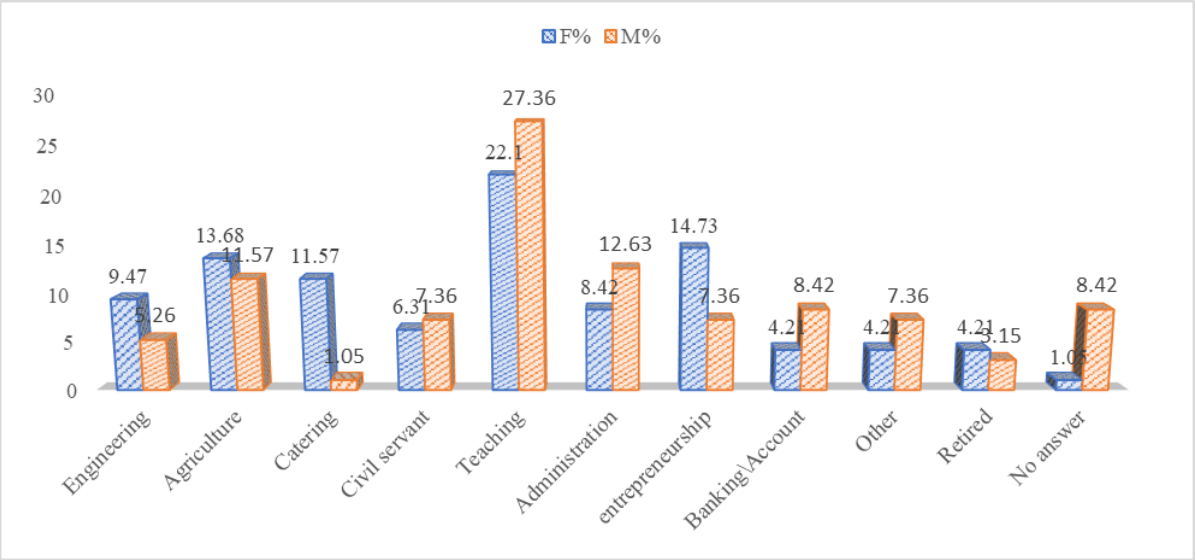

Figure 4: Parents' profession: F% for Father and M% for Mother

The rest of the students had their parents employed in non-engineering-related fields. Concerning fathers' professions, about 22.1% had fathers in teaching and related fields; the second group category of about 14.73% had fathers in entrepreneurship and related fields. For mothers' occupations, out of the total who responded to the question that is 91.57%, 27.36% had their mothers in teaching and related fields, which represents the highest percentage of all the group categories, followed by 12.63% of the participants who had their mothers in administration and related field. Overall, teaching prevailed, giving a total of 49.46%, followed by agriculture and entrepreneurship, each with 24% and 22%, respectively. A few participantts (9.47%) did not provide any answer to this question.

However, during the interview, the few participants (5.26%) who had a mother engineer admitted that the presence of the female engineer also significantly impacted their decision to choose the engineering field. Parents are sometimes the primary sources of inspiration for students' STEM-related educational choices. When parents are engaged in STEM careers, they often serve as models, making the STEM-related choices familiar to their children (Sjaastad 2012). Moreover, the regular intervention of female and counter-stereotypical role models in the classroom positively influences students' (both girls and boys) attitudes towards women in STEM (McGuire et al. 2020; Shin, Levy, and London 2016). The most influential role models are those who share a similar background with the students; this similarity can encourage girls to envision themselves in similar roles (Zirkel 2002). These female engineers may not only serve as positive role models who have the power to influence the girls' actions but also inspire these students to try for the standard they have set.

"My mum is a civil engineer by profession. I have had the privilege of seeing her manage some construction projects around Yaounde and other areas. She has also been a source of inspiration to me, not only because she is an engineer but also because she is a woman who is so good at what she does. Witnessing her achievements made me so confident that gender does not define one's ability to excel in engineering."

Community influence:

Surprisingly, a few participants (7.37%) revealed that engineering was not their desired career during the interview. They had no other option because their parents forced them to join the engineering field. Parents' influence decreases with age but is often still present in the initial choice of study options in higher education. Research has shown that teenagers are usually open to their parents' opinions (Ardies, Dierickx, and Van Strydonck, 2021). On top of this, in regions where most students are financially dependent on their parents during their studies, parents can even prevent their son or daughter from following a specific course of study. They highlighted that they make part of a community where families end respect the more, they have their children involved in STEM education or profession.

Consequently, every parent in the culture encourages or forces their children to join the engineering education to save the family from any shame. This situation is also regarded as a kind of pride and competitive spirit the community instils in their children. However, the students mentioned that being an engineering student has

equally made them start appreciating the field. What a blending mindset in Cameroon, wherein the same country, it is possible to find parents and cultures that do not give high value to girls' education. On the other hand, parents force girls to choose promising fields of study, such as engineering.

I am an engineer because my parents obliged me to join the field. We grew up in an environment where there was competition among families. Families with children who excel in science are highly respected and serve as an example.

The question in such a situation is, what if the children concerned cannot be qualified as STEM students or never develop an interest in the engineering field?

4.2 Findings related to the second research aim

The second research objective aimed to identify the obstacles encountered by women in engineering at the National and Advanced School of Mines and Petroleum Industries (NASMPI) in Cameroon. Based on the interview and questionnaire data, the points obtained are discussed as follows;

4.2.1. Nature of the field (Curriculum)

Engineering is well known as one of the most challenging fields of study, and it requires time, energy, problem-solving skills, resilience, and academic efforts to succeed. The field's nature significantly shapes the students' challenges and educational experiences. The engineering program at NASMPI is known for its challenging nature, requiring a deep understanding of pure scientific courses encompassing mathematics, physics and technical ideas. A few participants (8.43%) reported that the difficult nature of the field frequently stretched their intellectual capabilities and required much dedication, making it challenging. They noted that, due to the dynamic nature of the field, they have to devote significant time to learning and conducting research to remain updated with new technologies.

Apart from the long hours of lectures and assignments, not to mention the fact that I do not have enough personal time for relaxing or doing other things, I have to spend much time on research and studies to remain abreast with the fast-paced technology, leading to stress and fatigue. These make this field unique and very tough.

However, most participants (91.57%) expressed excitement about the curriculum. The main points cited here are that some students are curious and passionate about the field, exposed to engineering concepts, activities and practical experience through internships and fieldwork, especially during Industrial activity, which is compulsory (8 to12 weeks) for 3rd, 4th and 5th-year students in NASMPI. Also, workshop activities have significantly influenced their perception of the field, making engineering particularly interesting to them. They precise that the curricula typically cover a wide range of technical subjects, and these courses are gender-neutral. They emphasised that the content of the courses taught is intended to provide all students with a solid foundation in engineering skills.

Honestly, the curriculum is very challenging; however, the engineering aspects, internship period, and field trip moments make it extraordinary. Women and men can find a way out in this field because the programs are gender-neutral.

Engineering is not limited by gender, and anyone with an interest, passion, and aptitude for engineering can pursue a successful career. Silfver et al. (2022) also support this point that gender does not matter; instead, hard work in school and the experiences of the individual, thus making it 'no problem' for women to enter a male-dominated area such as engineering. Women have significantly contributed to various engineering disciplines throughout history and continue to do so today. They even mentioned that female students had outstanding results compared to male students in some classes due to their knowledge, skills, aptitude, and dedication to their studies. The studies conclude that performance in engineering, like any field, is not solely determined by gender. Instead, it is shaped by individual abilities, effort, resource access, and other factors.

4.2.2. Treatment of the female students

The treatment ladies receive in academic and professional milieu may act as a push force or barrier to their success. Interviews with female students and graduates from NASMPI revealed how women are treated. From the survey reports, most students (86.31%) said their male counterparts and teachers treat them well. They pointed out that some lecturers kept encouraging them to work extra hard to use their advantage in a male-dominated field. The lecturers provided academic help to build self-esteem. A similar result is found in Powell, Dainty, and Bagilhole's (2012) interview, where lecturers legitimately offer women students more help because they appear less confident with their work than male students in the engineering field. However, during the interview, they expressed their disappointment about some female engineering students; how they behave poorly,

gives the male students and teachers a wrong impression of them. The male students end up saying that the girls use their bodies to acquire good grades from teachers. This behaviour reduces the respect they have for women in the field.

Some teachers encourage us and advise us to take the scarcity of women in engineering as an advantage.

Another student hinted:

We are in a male-dominated field, of course, it's an advantage, but I am not too fond of the way some of the girls make themselves cheap. They do not behave appropriately. This tarnishes our image in the eyes of teachers and male counterparts.

4.2.3. Gender Stereotypes and Harassment

Few of these participants (10.51%) reported encountering stereotypes. They highlighted that some of their teachers consider them weaker students in technological courses because their opinions and ideas were given less credit. Hence, some teachers pay more attention to their male counterparts than females during lectures and exercises in class, which strongly discourages them. As a result, they are constantly under pressure and must put in more effort to earn the same recognition as their male peers.

Some teachers do not trust our ability to understand technical situations or software practice as our male counterparts. They pay more attention to the boys than us because they think they are fast at learning and understanding.

In Cameroon, cultural and traditional norms have long specified the role of men and women, and engineering is still regarded as a male profession. These women students sometimes faced stereotypes that questioned their ability and capability to be in the field. These biases were not limited to their male counterparts but also some lecturers, colleagues in the industries and even members of their communities. The constant desire to confront these challenges adds emotional and psychological burdens to their academic journey.

About 3.15% of these participants (graduates) experienced harassment from some of their teachers and male students. They reported that some teachers proposed good grades in exams in exchange for sexual activities, while some male students considered them like sexual objects. Consequently, this category of female students preferred only female students to form their class project team because they felt more comfortable and supported when working with girls who understand their experiences and challenges. It follows that girls who experienced harassment in this milieu can have significant and long-lasting impacts on the minds of targeted individuals, hence reducing academic performance and eventually decreasing their interest in pursuing engineering careers.

4.2.4. Psychological Challenges

The engineering program at NASMPI is notoriously demanding, challenging students to acquire problem-solving skills. The pressure to do well in a field commonly ascribed to males increases stress and the burden of work. According to some women (34.74%), fear of failure is a prevalent psychological challenge. The participants hinted that the high pressure associated with their studies and social expectations that women should perform well to gain respect in a male-dominated field create widespread anxiety about making mistakes. This fear can hinder some women from taking risks and engaging in innovative concepts crucial for engineering.

There is this constant fear of being unable to make it as the engineering field is regarded as male-dominated. So, we have to work harder to prove ourselves.

Constantly having to prove their competencies and dealing with prejudice can depreciate someone's self-confidence. Therefore, the psychological difficulties women engineering students and graduates experience may have a prolonged impact on their self-esteem. Nevertheless, women who successfully make it amid these difficulties become very confident because they have overcome giant obstacles. Also, the emotional and psychological issues they encounter may influence female career choices in engineering education or profession. Some females may choose to work in engineering or related fields and may seek to engage in programs encouraging other women to have an impact in the field. The cumulative emotional toll may cause others to hope to have a career in engineering and, thus, choose to seek fields where they can easily gain their place and value.

4.2.5. Limited role models and mentorship in the institution

The presence of role models and mentorship serve as a source of motivation for women, particularly in areas where they are underrepresented. However, the scarcity of female role models at NASMPI contributes to a sense of isolation among some students. About 30.53% of the participants emphasised that the lack of sufficient role models strengthens the perception that engineering is a male-dominated discipline, generating this feeling of self-doubt. Without role models to aspire to, the interviewees mentioned that they occasionally questioned if they

belonged to the engineering field, which sometimes negatively impacted their confidence.

It is rare to find potential women role models to look up to; I sometimes feel like, is this my place?

Female role models play a significant role in a field as challenging as engineering, where professional connections are a way to success. However, insufficient role models, including lecturers, industrial experts, visiting lecturers, and formal mentors, disadvantaged some women. This point corroborates with Dennehy and Dasgupta (2017), who highlighted the importance of mentorship as an effective tool in helping female engineering students increase their self-esteem and sense of belonging. Navigating the professional milieu to gain insight into the field and understand challenges linked to the engineering world is sometimes challenging without the orientation and support of experienced and expert women engineers. Stereotypes and social difficulties can be overcome and broken in engineering, where women are underrepresented, when female students can connect with successful female engineers.

4.2 Findings related to the third research aim

The third research objective aimed to identify the possible solutions that could help remedy the difficulties encountered by women in engineering at the National and Advanced School of Mines and Petroleum Industries (NASMPI) in Cameroon. Based on the interview and questionnaire data, the points obtained are discussed as follows.

4.3.1. Increasing awareness of stereotypes

Women's enrollment in engineering has long been influenced by gender stereotypes, generating barriers that may have an impact on their self-esteem, education and professional aspirations. These stereotypes and biases are present in Cameroon society to such an extent that it is sometimes challenging to progress or succeed in disciplines like engineering, which is regarded as a male profession. However, interviewees have emphasised some measures that could mitigate this prejudice. The interviewees highlighted developing and implementing gender sensitisation initiatives within academic institutions as an essential solution. This should aim to increase awareness of the harmful impacts of gender stereotypes and promote support for women in engineering education. Sensitisation programs on gender consciousness in the academic community have been demonstrated as one of the critical solutions to dispel prejudice among students and, thus, promote fair conduct in the educational realm, according to a study by Subrata Pradhan and Dr. Vineeta Dewan (2024). Therefore, raising awareness in the academic community about the prejudice that women sometimes experience in engineering can contribute to developing a more encouraging environment where female and male students can follow their interests without fear.

Moreover, the interviewees suggested curriculum reform to eradicate gender stereotypes in the classroom. This strategy is supported by Hardtke et al. (2022), where students understand and become more sensitive to gender issues when exposed to such a topic in their curriculum. According to the respondents, to support students in understanding and analysing societal stereotypes and their impacts on education and careers, it is imperative to incorporate gender role discussion and gender studies within the engineering curriculum. Students can acquire a more profound comprehension of gender stereotypes. They may help dispel the obstacles that hinder women from pursuing their careers in engineering by openly discussing such issues in the classroom.

4.3.2. Promote the visibility of female role models

The interviewees suggested that promoting and increasing the visibility of outstanding female engineers in the academic and professional milieu can encourage present and future students in the field. They stressed inviting successful women in the field as guest lecturers, enabling them to participate in panel discussions and have their achievements published by the institutions. The visibility of ingroup experts, like female engineers, can act as a social solution to stereotypes, thus reducing the negative effect of engineering being a male profession. Therefore, female students and those who aspire to become engineers can be motivated and have the confidence to persevere and pursue engineering studies by seeing accomplished women who have successfully overcome difficulties in a male-dominated profession. Moreover, encouraging more women to pursue engineering by encouraging engineering schools to conduct awareness campaigns and training programs to inculcate engineering and technology values in them. These programs should focus on unconscious biases and stereotypes within the engineering community. Female students might know the growing number of opportunities and initiatives to promote women in engineering and break down traditional gender barriers in STEM careers.

4.3.3. Mentorship network

Based on the findings, the study suggests developing a formal mentorship program at NASMPI. Mentorship is essential for supporting students amid both academic and professional challenges. Through this program, the

institution can maintain a connection between female students and experienced female engineers; hence, the students can gain professional advice, guidance and mentorship. The mentorship program may contain networking opportunities, workshops and meetings. In addition to offering mentees sound guidance, the mentors could provide emotional support to help the students develop strong resilience and self-confidence. Furthermore, peer mentoring programs can also be an efficient measure to support women in engineering. It may involve pairing senior female students with junior students, where experiences and strategies to progress in the field can be shared. Such a strategy can limit the feeling of loneliness and thus establish a strong support network system among women. This has been demonstrated in studies by Fox, Sonnert, and Nikiforova (2011) that peer mentors are realistic role models who have experienced identical difficulties, which could enable them to share self-experience strategies and make their valuable guidance to new students.

4.3.4. Institutional support (Inclusive environment)

The study also highlights institutional commitment to support female students in this field. There is a need to back the development of female role models and the creation of mentorship programs by establishing laws and policies promoting women's engagement in engineering. The school should encourage an inclusive classroom environment where discriminatory behaviours and harassment are sanctioned to increase awareness among students and teachers about female students' challenges. A supportive learning environment where women thrive depends on institutional policies prioritising gender equality (UNESCO 2017). Such measures can significantly enhance female engineering students' success and retention rate while ensuring commitment to address these challenges.

5. Conclusion

In this research, we shared the findings of a study designed to unveil the experiences and challenges women students face in engineering schools, their motivation to study engineering and, subsequently, the possible solutions to overcome the obstacles, taking NASMPI as a case study. About 43.15 % of the participant's fathers are university graduates, while 38.94% of their mothers completed tertiary education. The findings showed that parents' education can influence women's choice of study. Most women in engineering were expected to pursue engineering because their parents were in the field. Nevertheless, only a few participants had one of their parents involved in engineering.

The results showed that 42.1% of these young women are motivated by an unweaving interest in engineering. During interview it was noticed that such a group of individuals have self-confidence, intrinsic motivation, the skill and knowledge to do the work, and self-identify as STEM lady. The interview conducted reveal how the students were ready to face any challenge in order to fulfil their dreams of becoming STEM professionals. The inner environment may act as filter that alters a person's opinion of the larger environment (Mozahem et al. 2019). This explains how some individuals cannot be affected by what the society holds as an opinion (negative) but are driven by their determination and power.

However, a few students (7.37%) sincerely mentioned that engineering was not their desired career. On the other hand, a few of the participants (8.42%) declared that the field demands much dedication, making it challenging. Few of these young women, 13.66%, complain about their teachers considering them weaker than their male counterparts and also experience harassment from some teachers and male students. The interview results shows that women still go through such giant obstacles.

The journey of women in engineering education showcase determination, resilience and hard work to contribute in the society and overcome societal prejudice. Facing obstacles such as limited role models and mentorships, toughness of the engineering field and gender stereotypes, however, these ladies continue to demonstrate their strength in a male dominated field. Remedies like increasing awareness of stereotypes, promoting the visibility of female role models, establishing mentorship network and inclusive environment will contribute to sustain present women in the field and attract more future passionate women.

There is enough evidence that female students and graduates faced numerous gender-related challenges in studying in engineering schools. Overcoming these challenges is an ongoing process that requires the collective implication and effort of the entire academic community (government, policymakers, students, staff and administration) to create a supportive educational milieu where both genders are encouraged and empowered to choose and succeed in the engineering field. By giving more attention to the safety and well-being of everyone, engineering institutions can build an environment where all students can thrive and pursue their dreams without fear. Although female students at NASMPI currently make up less than 35% of the total population, there is still

a need for many more females in engineering to satisfy the gender balance in the engineering labour market. Equity is beyond achieving a numerical balance between men and women. It emphasises ensuring all individuals have equal access to opportunities, resources, and support, regardless of their background, social status, culture or circumstances.

Suggested future works include developing a software package to facilitate the WOZIP data input and conversion processes, exploring the use of WOZIP in the other forms of labour-intensive manufacturing (e.g. flow-line production and work-cell assembly), and attaching a costing framework to determine the specific cost of each resource or to help minimise the aggregate cost of production.

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