

# Gender and Civil Engineering in Higher Education: The Case of Mauritius

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## Abstract

Engineering plays a crucial role in everyday life and is the backbone of growth and development of the world including Mauritius. To embrace development, higher education institutions have to ensure that students are equipped with appropriate knowledge and skills to meet the needs of the country. Unfortunately, data shows that there is an underlying gender disparity in civil engineering training in higher education. It is imperative to understand the causes of gender inequity in engineering in higher education. This paper summarises the findings obtained from in-depth critical individual conversations with three participants, which explored the under-representation of undergraduate female students in a civil engineering degree in a higher education institution in Mauritius. The aim was to find ways in which the recruitment of female students in higher education and advancement of women in the field of civil engineering can be achieved. The findings support the ‘non-visibility’ of civil engineering as a field to study by women and the need to fit in as an engineer by women. As a result of the research, recommendations were made to assist policy and decision makers to develop evidence-based policies to address gender inequity in engineering in higher education.

**Keywords:** Civil engineering, female engineering student, higher education

## 1. Introduction

### 1.1 Introduce the Problem

In 2014, women constituted only 25% of the engineering majors such as Manufacturing, Mechanical, Mechatronics, Civil, Electrical and Electronic Engineering in higher education in Mauritius (Tertiary Education Commission, 2014). Engineering thus remains under-represented by women in Mauritius. The statistics at the higher education institution where the research was conducted, showed that efforts to improve the gender profile in civil engineering have had limited success (Tertiary Education Commission, 2019, p. 25). It is still true that female students in engineering often have to cope with a “chilly” environment (Flam, 1991), and feelings of non-belonging (Walton and Cohen, 2007), which can lead to negative wellbeing outcomes (Cohen, Garcia, Purdie-Vaughns, Apfel & Brzustoski, 2009). This essentially leads to a situation where female students are entering the field at a cost that perhaps explains why female students continue to be discouraged from studying a civil engineering major. Critical individual conversations were employed to capture current female engineering students’ experiences towards civil engineering and gender. The hypothesis was that gender would be an important factor shaping the experiences of the female engineering students. This study aimed at answering the following two research questions:

- a) What are the factors influencing the participation of female students in civil engineering?
- b) How are these factors influencing the participation of female students in civil engineering?

### 1.2 Significance of the Study

As education is an important pillar of any economy, civil engineering is equally important to Mauritius being a developing country, as on one hand, it is in a phase when major infrastructural developments are taking place. On the other hand, it is fundamental that gender equity becomes the norm in all spheres of society. This study elaborates on the challenges facing female engineering students and the conclusion and recommendations of this study may assist as a guiding tool for effective recruitment of female students in the civil engineering field. Civil engineering in the higher education sector and gender are considerably under-researched in the Mauritian context and the study has contributed to this body of knowledge.

## 2. Literature Review

### 2.1 Engineering as a Gendered Field

In acquiring a formal education that would lead to traditional skills, women do less well in acquiring the specific technical skills that appear most relevant to science, engineering and technology (SET) (Walby, 2011). The gendered structure of the engineering culture is an addition to the male dominant construct of societies and “the gendered aspects in engineering are ideological and are based on a complex web of general and particular discourses around traditional gender roles, technical know-how, masculine “hardness” and feminine “softness” ” (Kadayifci, 2018, p. 222). Beliefs of masculinised technical aspects of engineering build a gendered hierarchy that disadvantages those with a work style considered as feminine (Leyva, Massa & Battey, 2016). Physical work such as lifting of heavy objects characterises the stereotypical image of a male engineer (Tabassum, 2015, p. 137). A gendered imagery and stereotyping of engineers and the engineering profession become a reinforcing cycle where the women who enter the profession are seen as outsiders in a ‘male’ profession and any engineer not ‘building and fixing’ is seen as performing lesser and doing unimportant work (Tabassum, 2015, p. 134). Moreover, work and family culture are highly gendered, informing the gendered divisions of domestic labour and childcare (Herman, 2015, pp. 15-16). Whether at work, in academia or at home, engineering is considered as a gendered field where male narrative is the trend.

### 2.2 Experiences of Female Students in Academia

Education is the backbone for progress of any country and is one of the most important indicators for developing countries to achieve sustainable growth. Also, education is seen as the main input for a society to be considered a knowledge society (Demir, Genc, Alp and Yildirim, 2015). Some of the obstacles for women emphasised in research are that STEM subjects can be seen as difficult to learn (Khairani, 2017, p. 2) and the struggle of moving from school to higher education (Simon, Aulls, Dedic, Hubbard & Hall, 2015, p. 5). Other studies have found that women are attracted to STEM fields which they believe will allow them to help others and benefit society (Goy, Wong, Low, Noor, Fazli-Khalaf, Onyeneho, ... & GinikaUzoigwe, 2018, p. 14). Women’s choices are constrained by societal factors, particularly their stereotypes about the kind of people, the work involved, and the values of these fields (Cheryan, Master & Meltzoff, 2015). Interactions with male students, particularly through group projects were some of the most common contexts for experiences of gendered dynamics in academia (Smith & Gayles, 2018, p. 9). Such continued structural and sociocultural challenges in academic settings negatively contribute to women’s experiences in engineering. The climate in STEM classroom can also establish a barrier to women in STEM subjects (Mbanjo & Nolan, 2017, p. 58). Women experienced implicit bias in a variety of interactions and environments, especially from male peers in team projects where women’s contributions were overlooked and thus discouraged the participants to contribute to team works (Smith & Gayles, 2018, p. 18). This showed that the female students experienced adverse power dynamics which shaped their experiences. Women were expected to adapt to male-dominated, unfriendly, and, often, sexist environments in academia (Smith & Gayles, 2018, p. 18). Female engineering students are constrained and mediated to a great extent by sociocultural values and expectations ascribed to their traditional social and cultural roles; for example a possible self as the main child carer (Papafilippou & Bentley, 2017, p. 12). The gendered composition of SET might be a consequence of the gendered culture of science and technology (Walby, 2011), thus resulting in the under-representation of women in SET. “This inverse relationship between societal levels of gender equality and gender equality in STEM related educational choices and outcomes, suggests that culture, manifested in gender norms, is not a single factor but rather a multiplicity of forces shaping educational outcomes” (Friedman-Sokuler & Justman, 2019, p. 33). The presence of power dynamics was very much present in academia which shaped the learning experiences of the female students.

### 2.3 Attributes of Civil Engineering

Studies suggest that success in STEM subjects is considered to require innate intelligence, ability and skills that are against a gender cultural stereotype (Wang & Degol, 2017). Despite a number of efforts to change the perception of engineering, it is still male-dominated (Thackeray, 2016), which is again seen as a barrier for women. Further, for women who choose engineering, classroom experiences can serve as a barrier at many levels towards career progression and retention. Women who feel that they must adapt themselves to a traditionally masculine culture (Di Bella & Crisp, 2016) can feel demotivated in a competitive male-dominated environment (Shedlosky-Shoemaker and Fautch, 2015). To achieve acceptance in the field, some female students have compromised by copying their male peers. Unfortunately, this reinforces perceptions of civil engineering as unsuitable for women. Therefore, to increase female recruitment in civil engineering, it is important that female students are aware of the career opportunities as well as a gender flexible working environment associated with civil engineering careers.

## 2.4 Influence of Family

According to Dabney, Chakraverty and Tai (2013), family is consistently mentioned as an instrumental source of support. Parents provide a sheltered and supportive learning environment replenishing participants' confidence and willingness to participate in STEM contexts. "Family support was one key difference between high school students who maintained their interest in pursuing a STEM career throughout high school compared to peers who lost that interest" (Aschbacher et al., 2010). Parents are children's first and primary socialising agents and they are responsible in shaping children's beliefs about and exposure to science (Simpkins, Fredricks, & Eccles, 2015). Moreover, the larger cultural milieu, inclusive of gender roles, cultural practices, and ethnic stereotypes, is theorised to shape youths' motivational beliefs through its influence on youths' immediate environments (Wigfield, Eccles, Fredricks, Simpkins, Roeser & Schiefele, 2015). For example, societal gender role beliefs about whether science in general or specific areas of science are more appropriate for males than females influence parental beliefs, which in turn shape whether parents encourage science more for their sons than daughters (Simpkins, Fredricks, & Eccles, 2015). Therefore, gender and cultural differences in STEM are theorised to be partially the result of environmental and socialisation differences at home and more approximately in educational institutions.

## 3. Methodology

In-depth critical individual conversations with three undergraduate female civil engineering students helped to understand their choice of field of study and experiences. At least two critical individual conversations were conducted with the participants in February and March 2019. In the first meeting, the participants were briefed and then asked to sign a consent form informing them that they could leave at any time during the process and that whatever they would discuss, would be confidential and anonymous. In the study, pseudonyms were used to refer to the participants to ensure the anonymity and confidentiality of the information provided by participants – Salima from Year 2, Nisha from Year 1 and Emma from Year 1 enrolled on a civil engineering major. As the participants enjoyed the conversations, this enabled me to probe and explore meanings, interpretations and concerns held by the participants. Lindegger (2010) recognises the usefulness of audio tapes as a method of recording critical individual conversations as, according to Lindegger (2010, p. 461), keeping audio recording of critical individual conversations assists in overcoming the problems with validity of information. Lindegger (2010, p. 461) further mentions that case studies often use video or audio tapes to record data. In line with this understanding and with the permission of the participants, I used a smart phone to audio record the critical individual conversations. The duration of each critical individual conversation was approximately one hour and the critical individual conversations usually took place during lunch breaks in the campus of the university. Each critical individual conversation was audio recorded and was conducted in 'Kreol Morisien' – language spoken in Mauritius. Each critical individual conversation was transcribed verbatim in Kreol Morisien and then translated and transcribed in English Language.

One major limitation to the study was the sample size. Unfortunately, this was due to the very low number of women studying civil engineering in Mauritius is low. The topics of the critical individual conversations focused on the relationship with male peers, relationship with academic teaching staff and choice of degree subject.

## 4. Findings and Discussions

The data was analysed using a thematic approach. Several themes emerged from the responses and these were grouped according to confidence, choice of degree subject and image of civil engineering. Generally, participants talked in negative terms about their study experience. Most participants agreed that they have equal status with men on their degree programme and that there is no difference in the way women and men treated. However, several themes emerged that portrayed a challenging learning environment for women students. Key amongst these was the belief that male students feel threatened by women on the course, the necessity for women to earn credibility, and the costs faced by women as a result of taking corrective measures to align to a male dominant culture.

### 4.1 Confidence

The gender gap in self-confidence began to widen during the first days at university. This was demonstrated when some male peers stared at the female students when they entered the classroom on their first day. This indicated higher level of self-confidence amongst the male peers and female students report higher levels of anxiety and lower levels of confidence about their abilities in the civil engineering field. Participants reported that this was mainly due to their attendance in single-sex secondary schools that created a more comfortable environment for asking questions and increased their confidence in their technological competence. Women in STEM fields face an unwelcoming environment (Herrmann, Adelman, Bodford, Graudejus, Okun & Kwan, 2016, p. 263). The environment during their

first days at university adversely influenced the confidence of the female students in the civil engineering field and this was demonstrated when Emma highlighted the following:

*“It was strange. Initially, I was quite uncomfortable, because I belonged to the minority group of students in class that is the girls. At the beginning, I hesitated to talk to the boys and made friends with the girls of the class only.”*

Self-confidence was also indicated by students’ beliefs that civil engineering encompasses difficulties. Female students had a general belief about one’s ability to be successful in the civil engineering field and they often had less confidence in their competence on tasks they thought of as masculine. This was indicated by Emma who experienced a sense of unworthiness after a male peer felt that civil engineering was not apt for female students as shown below:

*“Whenever, a lecturer would ask a question to a girl in class, the same boy would reply “What’s the use of asking her, she will not know the answer Sir””*

Women tend to be less confident than men (De Paola, Gioia & Scoppa, 2015, p. 6). The findings also showed that there was a high level of agreement from female participants that male students tended to be more confident in their abilities than female students as indicated by Emma below:

*“I must say that in Year 1, I had to work very hard to score high marks. The modules were very difficult and different compared to Cambridge Higher School Certificate examinations. Moreover, I also had to struggle to adapt to the new environment especially with the boys in the class and their behaviour.”*

The male students felt a need to demonstrate their superiority especially in class as shown below by Emma:

*“I remember once a male peer scored high marks in an assignment and when the other male peer asked the him about how he did to answer the questions correctly, the latter replied that “stop bothering me with that, later I will tell you” or “I left the answer sheet at home”. Many of the male peers are very competitive amongst themselves.”*

*“So he was not listening to the girls and kept talking to the lecturer. The lecturer asked him to listen to what the girls were saying. He said that what the two girls were saying was wrong and did not agree at all.”*

The fact that many male students appeared to rate their abilities far higher than the female students, intensified the additional effort that women must make in order prove their worth on the programme and to make their place as shown by Emma below:

*“When I was in Year 1, I scored the highest mark in a written class test in Mathematics 1. I was so happy, that’s because I really enjoy doing mathematics...When the lecturer was returning the answer sheet, he said that I was the only one to score full marks and also added that the others could have done better.”*

Thus, scoring the highest marks in an assessment, encouraged the interest of women and these high marks affirmed their confidence in the civil engineering field. The above vignette indicated that there was an increase of interest or confidence amongst female students when they performed well academically.

Out of school extra-curricular work was seen as an integral part of the STEM school experience as it provided different civic engagement opportunities with several organisations that gave students opportunities to visit universities and research centers to discuss scientific and engineering ideas (El Nagdi & Roehrig, 2019). Extra-curricular activities were an essential component of gender equity intervention and many out-of-school activities played an integral role in shaping interest and confidence in STEM. This was experienced by Salima who behaved like ‘men’ to be accepted in the boys’ group as shown below:

*“I am the only girl who plays football with the boys. The other girls just watch the matches and they support me. In fact the other girls don’t know how to play football.”*

Women are more likely than men to be excluded from a wide range of skilled and professional jobs in STEM (Tizard, Blatchford, Burke, Farquhar & Plewis, 2017, p. 7). Some teachers highlighted the importance of allowing adequate time for practice to increase familiarity with equipment in STEM (Hamner, Cross, Zito, Bernstein & Mutch-Jones, 2016). More time and experience with building components such as exploring a building environment increased women’s building confidence, and this was demonstrated by Nisha as follows:

*“I have watched the making of the Burj Khalifa in Dubai and the construction of La Tour Eiffel on YouTube. That was amazing. In the making of Burj Khalifa, how the materials were chosen by the engineers and how the workers had to carry each material to the top of the Burj Khalifa during its construction. You should watch it also. You will see how fascinating it is.”*

The findings showed that women lacked confidence in their abilities, and they had low expectations of themselves when compared to men. However, when their self-esteem was boosted, their confidence was also increased. Success in engineering was, therefore, more related with confidence than with competence.

#### 4.2 Choice of Degree Subject

Both the participants experienced positive encouragement to consider civil engineering from the family and that civil engineering was not a conventional choice for women. Two of the participants had relatives who were engineers or had some connection with civil engineering. In most of these cases, they had often been encouraged to consider civil engineering. The participants indicated that they had chosen civil engineering because they are good at science and maths and found it to be a discipline that combined these interests. However, the majority of participants agreed that civil engineering had not been presented to them as an option to aspire to whilst they were at secondary school. The family socio-economic status of the participants had an effect on the choice of degree subject in civil engineering. Higher status parents who were themselves engineers had raised parental aspirations that, in turn, were passed on to their children both as expectations and beliefs in their own capabilities and academic aspirations.

The motivation and achievement of STEM of the female students were also related to the quality of parent-child science interactions, such as types of explanations parents used at home or the extent to which interactions were intrinsically focused or emphasised mastery goals. Some parents encourage their daughters to play with non-feminine toys and thus this suggests that the influences of socialisation are largely at play (Wang & Degol, 2017). Emma benefitted from such types of experiences/experiments at home which contributed to her interest in engineering, as shown below:

*“when I was in secondary school, my brother and myself would sit next to my grandfather to open up and repair all sorts of devices such as TV, fan and even his motorcycle.”*

From the interview data, the participants chose civil engineering because they had supportive family relationships, parents or siblings or relatives who recognised the value of formal education in engineering for women, and who encouraged an interest in engineering. Parents in STEM fields might also differ in the type of educational activities they promote in their children which could help shape their preferences and potentially help reduce gender stereotypes towards STEM fields and they could help promoting social networks and specific job knowledge, increasing the potential returns to achieving a STEM college degree (Anaya, Stafford and Zamarro, 2017, pp. 4-5). These students had higher levels of self-efficacy that was important in their decision to study civil engineering. This was illustrated by Emma as follows:

*“my brother has also inspired me a lot... He is a civil engineer. I remember, he told me that there are few girls in this field. For example..., where he works there is only one girl.”*

Nisha was also supported by a relative and by her father as indicated below:

*“Because I have a relative who has already done the same programme and is working at the Ministry of Public Infrastructure. He said that the programme is really interesting and tough as well... My dad yes. Because he is also an engineer but not civil.”*

As shown above, the choice of degree subject was influenced by family support. The absence of gender bias towards women that was the framing of gender equality in engineering was significantly noted. This social fairness to women in the family encouraged women to enter the engineering field.

#### 4.3 Image of Civil Engineering

Women still face hurdles (Ceci & Williams, 2015). Some of the female students had faced reactions from others to their choice of the civil engineering major. This served to remind them that their choice was atypical. The participants agreed that women in general are not sure what an engineer does, or they think that a civil engineer should always be working on the field. This was reported in Salima's findings as shown below:

*“I don't know why girls do not engage in engineering field. If girls can do Science subjects up to HSC, then they can definitely do engineering.”*

It was found that “parental involvement discouraged students from taking advanced math and science courses, possibly because overly involved parents may actually deter a student from developing independence” (Gottfried, Owens, Williams, Kim & Musto, 2017, p. 9). In this study, some parents also had gender bias beliefs that civil engineering is not fit for women as shown by Nisha who was inspired by her father but was also discouraged to pursue a degree in civil engineering by her mother as shown below:

*“But my mum was a bit reluctant. She said that civil engineering is not too appropriate for girls... She told me that she preferred that I study other engineering fields instead of civil engineering because going on field when I will work, will be difficult for a girl and to be surrounded by mostly men. She mentioned that if I do other engineering fields it will be more suitable for me as a woman.”*

Civil engineering was often categorised as a characteristic of body competence typically attributed to men. This was also the beliefs of the male peers. This was shown by Nisha as follows:

*“I tell them that I may appear to be fragile physically but I consider myself as being a tough girl. Whether they like it or not, I will do my best to excel in my studies and graduate with a first class.”*

Beliefs about civil engineering and body image showed that the male students had an advantage compared to female students because men find a greater range of ideal body image (being muscular) more socially accepted in the civil engineering field. Furthermore, the findings showed that the frailty of some female students proved to be challenging to their success in the field.

## **5. Recommendations**

The findings show that there have been limited support initiatives to increase female participation and progression in civil engineering. The women who become civil engineering students in higher education feel the need to gain trustworthiness and make compromises to ‘fit in’. The fundamental gendered culture of the civil engineering field discourages women from entering the field, because they are seen to experience an unfair advantage or imply that women need extra help. The perception that such experiences are discriminatory or ‘anti-men’, leaves women no basis on which to act collectively, or even in partnership with men. Primary and secondary schools are not necessarily giving female students the opportunity to find out about civil engineering which could motivate them to enter the field.

The following recommendations will assist to encourage female students to enter the civil engineering field in higher education institution in Mauritius:

### **a) Offer scholarships to women**

A positive discrimination by offering specific scholarships to female students studying engineering in higher education could help increase the number of women in engineering and decrease the gender disparity in engineering in higher education.

### **b) Promote interactive teaching and collaborative learning**

With effective use of appropriate teaching methods such as introduction of more interactive classrooms in civil engineering, the quality of higher education offered in higher education institutions will be enhanced. All academic teaching staff will integrate more class discussions in their teaching process and thus there will be collaborative learning irrespective of gender. This will give rise to more effective learning by the students as the delivery of lectures will be enjoyable and up-to-date with contextual examples, and such strategies concur with the concept of applied engineering. Moreover, students’ achievement across gender will validate interactive teaching methods.

### **c) Promote the civil engineering culture in the society**

In order to promote the civil engineering culture amongst women in the country, Government should promote awareness programmes to encourage women to study civil engineering and its benefits and extend such programmes to women across the country irrespective of age. Awareness programmes could be conducted at the first instance in community centres across the island which would reach families across the island.

### **d) Promote collaborative linkages with industry**

Higher education institutions should have more collaborative linkages with organisations/institutions whereby engineers especially female engineers could be an inspiration to the students and could share their experiences with female students. Regular meetings with successful engineers will motivate the students to excel in their studies for career satisfaction and a rewarding salary. Female engineering students should be encouraged to start a career in civil engineering for reasons of financial independence, the high social status associated with this field, the opportunity to engage in creative and challenging projects and the wide range of career opportunities.

### **e) Strengthen financial support to higher education institutions (both public and private)**

Government may consider increasing the fund granted to public higher education institutions. This will enable the public higher education institutions to improve laboratories’ infrastructure (well-equipped laboratories with all the latest equipment; well-designed digital curriculum content without any gender bias). Private higher education

institutions could be granted funding, based on the size of their student population, to encourage them to invest in their laboratories. In the endeavour to help Mauritius become a developed country, it is imperative that the private and public higher education institutions collaborate.

## 6. Conclusion

The unspoken negative stigma that women are less competent than men in civil engineering is an intense discrimination against them. The stereotyping that civil engineering requires a lot of physical fitness and hands-on work on machinery, is too technical for women and requires working in a less women-friendly environment, discourages female students to enter the field and diminishes the self-confidence of those already in the field. A greater participation of women who could act as role models in the labour force especially in civil engineering could eventually increase the participation of female students in civil engineering in higher education.

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