



Gender Participation and Academic Perception Towards Teaching and Learning of Engineering Mathematics Course

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ARTICLE INFO

Article History:

Received: 12 June 2024

Received in revised form: 14 July 2024

Accepted: 21 August 2024

DOI: 10.14689/ejer.2024.112.05

Keywords

Female Participation, Engineering, Mathematics, Teaching, Learning.

ABSTRACT

Purpose: An overview of the teaching and learning of engineering mathematics among some engineering faculty and students in some universities around the world has shown that only few females participate in the teaching and learning of engineering mathematics courses during their undergraduate and postgraduate studies. This phenomenon can be linked to some complex mathematical content found in some engineering-related courses that has been stereotyped for the male gender. This has resulted in a shortage of female manpower in engineering arising year after year in South Africa. In view of this, this study aimed to examine the rate of female participation in engineering mathematics in the department of electronics engineering.

Methodology: This study was conducted with a sample of 16 engineering academics and students at a university in South Africa, using a mixed-methods approach. The process of data collection was done using an interview guide and a survey questionnaire. **Findings:** The result of the findings confirmed that out of 16 participants participated in the study, only 4 female participants adopted some engineering mathematics ideas into their teaching and learning of engineering-related courses, while 12 respondents who participated in the process of teaching and learning of engineering mathematics were males, who also benefitted with their knowledge of engineering mathematics. **Implications:** This study reports that if a low participation of female students in engineering mathematics is not addressed, the numbers of female engineers may drastically reduce and render a female underrepresentation in technical fields.

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Introduction

The engineering mathematics course is one such area of advanced mathematics which, due to its complex nature, has posed difficulty to learners across many universities, for it to be too hard to understand, apply, and integrate in real-life situations (Casey & Ganley, 2021). It was also added that, owing to hardships encountered by learners in understanding this course of

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engineering mathematics, inadvertently, this course became a male-dominated course. The argument was that there were a few theoretical concepts in this course of engineering mathematics that were too difficult for females to incorporate in their learning, due to their inferior, weak and fragile nature, and due to the lack of intellectual-capacity to grasp mathematics-related courses (Geyi, 2023; Tang & Zhao, 2024). When tested this argument, it was found that a few engineering mathematics courses such as antenna theory and engineering design, are predominately engineering-related courses and demand a lot of time and advance knowledge on mathematics (Wrigley-Asante, Ackah, & Frimpong, 2023).

Studies have revealed that owing to the difficulty faced by females to study engineering mathematics subject, it resulted in low enrolments of students in school of engineering education, which created a gap among genders in the field of engineering education (Rodriguez et al., 2020; Tang & Zhao, 2024; Wang et al., 2020). It was therefore accepted that low involvement of females in teaching and learning of advanced mathematics, is due to the deficit factors and the discomfort shown by female engineering faculty in teaching antenna theory and engineering design (Becker & Hall, 2024). In fact, one could say that the problem of low intake of female students has affected the number of female engineering faculty with practical knowledge of mathematics modelling in the engineering department (Madara & Cherotich, 2016).

However, after examining the curricula designed for engineering mathematics, particularly that of antenna theory and engineering design in a university in South Africa, it was found that the two topics were the part of several mathematics courses (CAES, 2020). Furthermore, it is also often argued that the worst part of this problem is the battle for gender popularity and a competition, in terms of the most important gender when it comes to mathematics, which affects the goal of teaching and learning in the field of engineering education (Luzano, 2024). A vast majority of previous studies have also confirmed that mathematics usage in science, technology, engineering, and mathematics education (STEM) has been improving from day to day in some developed countries like the United States of America, the United Kingdom, and some European countries, among many others, but not so in African countries like Nigeria and Kenya (Di Tommaso et al., 2024; Levine & Pantoja, 2021; Madara & Cherotich, 2016; Rodriguez et al., 2020).

Although female students receive about 44% of bachelor's degrees in mathematics in some developed countries compared to other subjects like computer science, which is invariably 18%, and this shows some improvement compared to males (Mejía-Rodríguez, Luyten, & Meelissen, 2021), but in Africa as a continent, it is not so. This fact is further evident in finding that female students in Africa exhibit anxiety and show a negative mind-set towards the complex engineering mathematics, which adversely affect their academic attitude towards engineering mathematics subject in general (Egara & Mosimege, 2023; Rodriguez et al., 2020). This argument was sustained by the fact that engineering mathematics was too difficult for females to grasp due to the lack of their intellectual-capacity (Geyi, 2023; Tang & Zhao, 2024). The hardship experienced by some female engineering faculty, when teaching mathematics courses, and female engineering students' laziness and indiscipline towards engineering mathematics, were found to be other contributing factors (Di Tommaso et al., 2024). The faculty's negative attitudes towards teaching of engineering mathematics and their poor engineering backgrounds also contributed negatively to this phenomenon (Aguillon et al., 2020; Egara & Mosimege, 2023). Furthermore, a poor mathematical foundation, the overcrowded classroom in mathematics lectures, lack of instructional materials, and inappropriate teaching methods adopted by some faculty, among

many others, have been taken as causes of low participation in the teaching and learning of engineering mathematics (Egara & Mosimege, 2023; Okeke et al., 2023a; Okeke et al., 2023b).

It is on this ground that some lecturers and instructors prefer to work with male students when it comes to engineering calculations, since they feel inherent barriers in sharing fluently their professional experience with female learners. Besides, the anxiety of female students and academics towards mathematics-related courses, the intake of female students in the department of engineering education has been affected in all countries. Studies have confirmed that female participation and enrolment remain at the lowest level in some higher institutions of learning in some developed countries as well (Hussein & Csikos, 2023; Madara & Cherotich, 2016; Wang et al., 2020). Table 1 presents a clear report on their participation in engineering courses.

Table 1

Representation of Gender Participation in Engineering Mathematics (Madara & Cherotich, 2016)

Gender	United Kingdom	United States	Australia
Female	9%	11%	14%
Male	91%	89%	86%
Total	100%	100%	100%

This tabular representation proves that there is an underrepresentation of women in engineering mathematics courses, which could be expressed as a multifaceted issue rooted in various social, cultural, educational, and environmental factors. Moreover, this phenomenon is historically based on the stereotypes and biases about engineering mathematics courses portrayed as a male-dominated field, which eventually discouraged females from pursuing these courses in their studies and careers (Jaremus et al., 2020; Johnson et al., 2020; Reinholz et al., 2022). As a result, educational environments got inadvertently perpetuated by gender biases, and negative attitudes and stereotypes about female's mathematical abilities affecting their participation (Aguillon et al., 2020). This perception is further compounded by the lack of female role models in mathematics, which also affected young female's confidence and interest in engineering mathematics subjects (Casey & Ganley, 2021).

The low participation of females in teaching and learning of engineering mathematics courses among engineering faculty and students in South Africa has not been addressed, despite the prevalent beliefs that there exists stereotypes and biases responsible for the lack of self-confidence among females, resulting in a consequent reluctance to pursue advanced studies in engineering mathematics (Jao, Hall, & Di Placido, 2024; Luzano, 2024; Msambwa et al., 2024; Tang & Zhao, 2024). To resolve this perennial problem, a dire need was felt to examine and understand the views of engineering academics and students about the level of participation of different genders in teaching and learning of engineering mathematics. Additionally, engineering mathematics as an advanced subject remains a complex mathematical concept taught to engineering students to prepare them for the practical usage of mathematics in handling engineering devices (Becker & Hall, 2024). Hence, considering the importance attached to engineering mathematics, the aim of this study was to investigate how to increase the participation of females in the teaching and learning of engineering mathematics subjects, and contribute as engineering experts in the industrial set-ups in their future. This study aimed to investigate the gender participations and collect

the views, opinions and perception of teachers and students for teaching and learning of engineering mathematics course took place in a university in South Africa. It is hoped that by studying their perception, it will help to recognize the gap between gender participations in the field of engineering mathematics and offer some solution.

Specifically, this study was guided by two research questions: (1) What are the levels of participation among different genders on engineering mathematics courses? (2) What are the views of engineering academics and students when teaching and learning engineering mathematics? The purpose of this study was to report the gender participation and suggest the possible way of improving the female enrolment in the department of engineering education, since they are the group that are affected with female's low participation in engineering education. In achieving the aim of the study, a mixed-methods approach was used as a method of conducting the study, using a survey questionnaire and an interview guide as tools for data collection. This study is important due to the open call for more female engineers to balance the deficit in female participation and build up the widening gap in engineering mathematics.

Literature Review

Recent studies on learning of engineering mathematics subjects have reported that there are different perspectives on teaching and learning of advanced mathematics, commonly found in engineering mathematics, due to its complex nature and the difficulty encountered when modelling them into learning (Oates et al., 2024; Pepin, Biehler, & Gueudet, 2021). Going by the views that engineering mathematics is a course with high concentration of mathematical concepts with some strong aspects of advanced mathematics which is common to the field of antenna theory and design (Rodriguez et al., 2020). Due to this assertion, engineering-related mathematics becomes a male-dominated course due to the complex mathematical concepts and hardships encountered when incorporating some aspects of mathematics into their teaching and learning (Jao et al., 2024; Msambwa et al., 2024). As a result of this, some engineering-related mathematics courses were reported as advanced mathematics courses that are too hard to understand, calculate, apply, integrate, and model in a real-life situation (Casey & Ganley, 2021). Furthermore, another report from engineering researchers argued that there are a few theoretical mathematics concepts embedded in some engineering mathematics subjects, (Geyi, 2023), which make it difficult for the females to grasp. The female students find it difficult to learn those subjects due to their beliefs and unwillingness to participate in engineering mathematics, and due to their inferior nature, weak nature, fragile nature, very dependent nature, and less-intellectual-capacity nature when it comes to mathematics-related courses (Geyi, 2023; Liu et al., 2022; Mateos-Moreno & Gallego-García, 2022; Tang & Zhao, 2024).

A report from the School of Engineering (SOE) at Moi University (MU) in Kenya recorded a mere 13% female students out of the total number of students admitted in the department of engineering mathematics (Madara & Cherotich, 2016). This implies that the teaching and learning of engineering mathematics has a low representation of females, while males continue to dominate the process. Kaiser and Zhu (2022) observed reported that male students scored six times higher than female students when modelling their mathematics ideas into teaching and learning of an engineering-related course, particularly in engineering mathematics. Furthermore, other studies have reiterated this low

participation of females in engineering mathematics, confirming distinct differences between male and female participation in engineering mathematics courses (Kaiser & Zhu, 2022; Setiawan et al., 2022; Wang et al., 2020). In addition to this, studies have also confirmed that there is a wide gap between male and female students taking mathematics-related courses both at the high school and at the university level (Becker & Hall, 2024; Kaiser & Zhu, 2022; Luo, 2022; Weimer, 2023).

It is obvious to note that the existence, degree, and origin of a gender gap in engineering mathematics has been of broad concern for decades in mathematics education (Casey & Ganley, 2021; Derkaoui et al., 2023). Several factors have contributed to this gender disparity in engineering mathematics, these include biological differences, thinking abilities, and having higher-order mathematical thinking, among many others. There are also cultural or societal factors, such as the stereotype of mathematics as a male domain or less support for female students in contrast (Jaremus et al., 2020; Kaiser & Zhu, 2022). Studies have narrated the low participation of females in teaching and learning mathematics, and observed that females are not even conversant in teaching and learning of general mathematics course, which is an elementary course in the science and engineering curriculum (Lazaar, Mhemdi, & Okbani, 2023; Msambwa et al., 2024; Sánchez-Medero & Pastor-Albaladejo, 2024). Academically, this low participation of female students to study engineering mathematics subjects is the general belief that these subjects are too difficult to comprehend, and can be tackled only by geniuses. The low participation in mathematics among female engineering students could also be linked with the fact that they did not receive adequate mathematics training while in school. It has also been asserted that due to the less participation of females in engineering mathematics, as compared to the males, it has resulted in poor job prospects for the female folk in the job market (Johnson et al., 2020; Kaiser & Zhu, 2022).

Theoretical Framework

There exist several theoretical frameworks and models on gender participation in teaching and learning of engineering mathematics in previous studies, that have suggested different theories relevant to gender equality among mathematics and engineering students. Among them are Bennett et al.'s (2021), socio-cognitive career theory (SCCT); Egara and Mosimege's (2023) computer simulation model; Weiss et al.'s (2003) verbal memory model; Kaiser and Zhu's (2022) socioeconomic model; and Schneider et al.'s (2022), didactical phenomenology, which assists in understanding the appropriate phenomenon required when teaching and learning mathematical domain in engineering-related courses. In view of this, didactical phenomenology and SCCT theory, with a few modifications, were judged as appropriate tools that can assist both genders in participating in teaching and learning of engineering mathematics subjects.

While considering the teaching and learning of engineering mathematics, the psychological perspective of female students needs special attention. As a result, it is vital to use a conceptual framework to determine the psychological condition of teachers and learners. Hence, it is required to incorporate the psychological aspect of the model when teaching and learning mathematics-related courses like engineering mathematics. This psychological aspect acts as a necessary tool because it requires both mental and psychological thinking of the participants, considering female's weak psychological

balance in a learning environment (Prediger, Gravemeijer, & Confrey, 2015). In addition, since engineering mathematics courses have been traumatic for female engineering students, it is also necessary to study their socio-cultural and professional interests as well.

It is also required to examine the truth of the statement that the loss of interest in mathematically related courses among females has resulted in low enrolment rate, thereby engineering becoming a male dominating profession (Tang & Zhao, 2024). It is also necessary to testify the belief that females drop out of school because of psychological traumas experienced. These statements are to be examined with respect to expectancy-value theory, which emphasizes the role of students' expectancy, values and expectations for future success as a result of decision-making and career choice-making (Ball et al., 2019; Casey & Ganley, 2021). Therefore, discussing the issue in hand in this study with a focus on expectancy-value theory remains important when speaking about gender participation in teaching and learning some mathematically related courses (Lubienski & Pinheiro, 2020; Rodriguez et al., 2020). On this note, the data collected from engineering academics and students gave rise to a new model known as the Gender Participatory Model in Engineering Education (See Figure 5), which is a schematic diagram to report the models that can assist different genders in participating in teaching and learning of engineering mathematics.

Methodology

Research Design

The study adopted a mixed method research design which ideally suited this study which had gathered both quantitative and qualitative data for the study. The mixed method approach is also helpful in examining the research questions of the study which examined the levels of participation of both genders in teaching and learning engineering subjects and also studied the perception and opinion of teachers and students for the issues and concerns raised in this study. Moreover, a mixed method approach is also useful in designing plans and strategies to carry out a study with varying parameters, requiring both numerical data and information related to attitude, perception and opinions of the study sample (Dubey & Kothari, 2022).

Sampling and Population

A sample comprising faculty and students from the engineering mathematics department of a South African university was chosen through a purposive and a systematic sampling method, as the population of the study was very diverse and inaccessible across the specialized subjects. Owing to the issues raised about the specific subjects of antenna theory and engineering design, there was also a need to include a few female engineering faculty and students learning and teaching these specific subjects. This was done to determine the accuracy of the stereotypes and biases and also to get an opportunity to probe and counter-examine the views of both male and female participants. A total of 16 participants comprising undergraduate and post graduate students and three faculty members were identified, despite excuses for non-participation given by the participants, such as the internet and the non-availability of time, among many others. The ethical clearance and written and verbal consent were collected by the researchers before the data adopted for this study was collected (Kumari et al., 2023).

Instrument and Research Procedure

A survey questionnaire was distributed to both learners and the faculty, followed by a one-to-one interview with selected few participants. The interview was conducted to validate the information retrieved from the questionnaires. The process of data collection was done using email and telephone due to the restrictions and COVID-19 rules as stated by the university. The data collection procedure involved collecting all questionnaires within a given deadline. After collecting the filled in questionnaires, the incomplete and invalid questionnaires were removed from the final analysis. The interviews were recorded and a transcript was prepared for content analysis. This transcript comprised opinions and views of the participants on teaching and learning of engineering mathematics courses. Therefore, the use of quantitative and qualitative approach was found to be necessary for the execution of the study (Verma, Verma, & Abhishek, 2024).

Data Analysis

The data collected from questionnaires and interviews were given in-depth analysis using a quantitative tool, software (SPSS) for the questionnaire data, and a thematic content analysis method for the interview data. At the analysis level, the first section of the open-ended survey questionnaire was used to analyze the first phase of the stated research question, while the second phase of the questionnaire and the interview guide were used to gather their views on the teaching and learning of engineering mathematics (Dubey & Kothari, 2022; Kumari et al., 2023; Verma et al., 2024). The detailed process of data collection and interpretation were hereby displaced below in line with the thematic report on the status and the views of the participants on engineering mathematics and their views on it.

Results

Reporting Gender Enrolment and Participation in Teaching and Learning of Engineering Mathematics

This section presents the findings of the first research question of the study: *What are the levels of participations among different genders on engineering mathematics courses?* As mentioned earlier, the data was gathered from electronics engineering faculty and students. This data reflected their views and opinions about teaching and learning engineering mathematics. While the survey questionnaire helped providing the numerical data analyzed through SPSS software, the data collected from interviews provided the rationale of the opinions and views expressed by them. The data regarding gender participation in teaching and learning engineering mathematics subject was analyzed in three categories: engineering faculty (academics), post graduate students and undergraduate students

Gender Participation in Teaching and Learning Engineering Mathematics Among Engineering Academics

Table 2 presents the frequency and percentage of the participation of male and female participants in teaching and learning of engineering mathematics in a university in South Africa. Out of the total participants (n=16), it was found that only 4 participants, 3 males and 1 female academic, participated in the teaching of engineering mathematics subject,

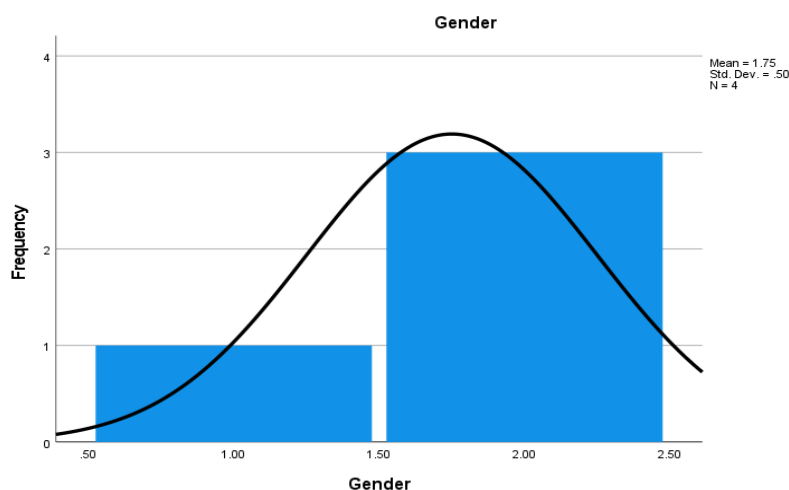
particularly the topics like antenna theory and engineering design. This available data shows that it is significant to know that 75% of male academics participated in the process of teaching mathematics in an engineering context, but it also indicated a low participation of female (only 25%) in teaching the engineering mathematics subject.

Table 2

Frequency and Percentage of Engineering Faculty in Teaching and Learning Engineering Mathematics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	1	6.3	25.0	25.0
	Male	3	18.8	75.0	100.0
	Total	4	25.0	100.0	
Missing	System	12	75.0		
	Total	16	100.0		

Figure 1 shows the frequency, mean and SD of engineering faculty that participated in teaching and learning of engineering mathematics subject. It is revealed that teaching and learning were done by only one female faculty while other academics were males. A low participation of females in teaching engineering mathematics was evident in the results, which was due to the poor involvement of females in teaching engineering mathematics subjects, and also because of anxiety about mathematical concepts involved in engineering-related mathematics (Pepin et al., 2021).



1 Represent Female Gender; 2 Represent Male Gender

Figure 1: Frequency, Means and Sd of Engineering Faculty in Teaching and Learning Engineering Mathematics.

Gender Participation in Teaching and Learning Engineering Mathematics Among Postgraduates' Students

Table 3 depicts the frequency and percentage of the participation of postgraduate students in learning engineering mathematics subject, particularly topics like antenna theory and

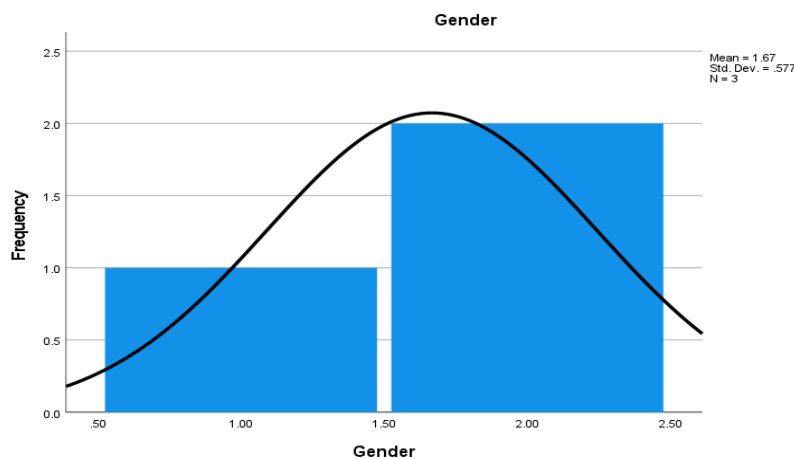
engineering design. The findings show that a majority of male postgraduate students (66.7%) participated in the processes of the teaching of engineering mathematics; however, a significant low participation rate of 33% of female post graduates was recorded among those who were learning engineering mathematics. This finding represents the status of gender involvement in learning engineering mathematics in subjects like antenna theory and engineering design course at engineering mathematics department in a South Africa university.

Table 3

Gender Participation in Engineering Mathematics Among Postgraduates' Students

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Female	1	6.3	33.3	33.3
	Male	2	12.5	66.7	100.0
	Total	3	18.8	100.0	
Missing	System	13	81,3		
Total		16	100.0		

This result corroborates with previous research studies which report that female participation in learning engineering mathematics is negligible because the engineering academics underrate female postgraduate students, in relation to learning the subject of engineering mathematics, which resulted in discouraging female involvement in engineering (Munachonga & Munsaka, 2019). Figure 2 validates this finding showing frequency, Mean and SD of genders that participated in learning engineering mathematics, and confirming the high dominance of male participants in learning of engineering mathematics among post graduates.



1 Represent Female Gender; 2 Represent Male Gender.

Figure 2: Gender Participation in Engineering Mathematics Among Postgraduates' Students.

Gender Participation in Teaching and Learning Engineering Mathematics Among Undergraduate Students

Table 4 is the presentation of the frequency and percentage of the participation of undergraduate students in learning engineering mathematics subject, particularly topics

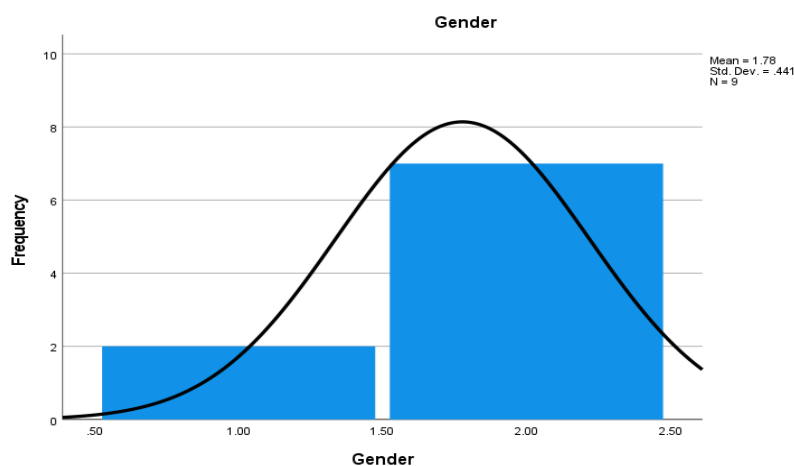
like antenna theory and engineering design. A total of nine undergraduate engineering students were identified for their participation, and to collect views and opinions about engineering mathematics in the department of engineering education. The findings show that a majority of male undergraduate students (7 participants, 77.8%) participated in the processes of the teaching of engineering mathematics; however, a significant low participation rate of (2 participants, 22.2%) female undergraduates was recorded among those who were earning engineering mathematics.

Table 4

Gender Participation in Engineering Mathematics Among Undergraduate Students

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Female	2	12.5	22.2	22.2
	Male	7	43.8	77.8	100.0
	Total	9	56.3	100.0	
Missing	System	7	43.8		
	Total	16	100.0		

It is clearly evident that the process of learning engineering mathematics in antenna theory and design was done only by fewer females (only two), while male participants dominated the process of learning, which remains a big challenge to the learning of engineering related courses. This finding corroborates with [Tang and Zhao \(2024\)](#), who argued that some of the present female students in the field of engineering still find it difficult to understand mathematics concepts and solve mathematical problems; this has resulted in a low level of student involvement in learning engineering mathematics ([Tang & Zhao, 2024](#)). [Figure 3](#) validates this finding showing frequency, Mean and SD of genders that participated in learning engineering mathematics, and confirming the high dominance of male participants in learning of engineering mathematics among undergraduates.



1 Represents Female Gender; 2 Represent Male Gender.

Figure 3: Gender Participation in Engineering Mathematics Among Undergraduate Students.

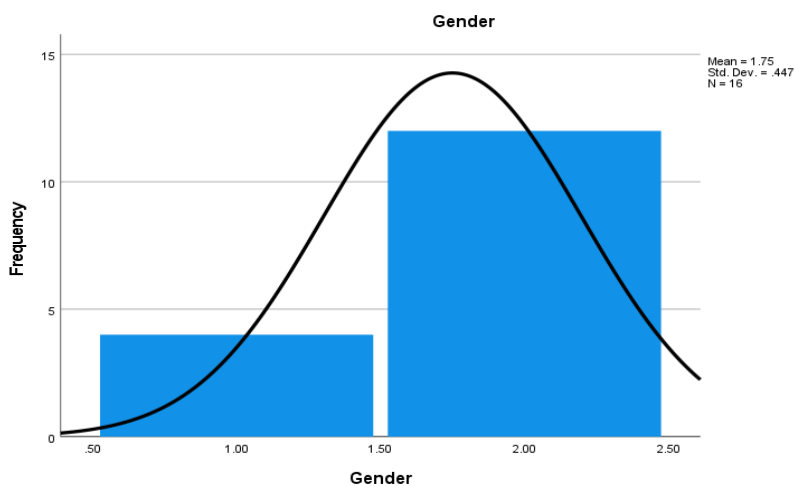
The study gave a comprehensive look at the overall participation of male and female academics, postgraduate students, and undergraduate students, who were involved in teaching and learning engineering mathematics, particularly theoretical and practical antenna theory and engineering design classes, in the department of engineering education at a university in South Africa. To sum up, a total of sixteen engineering academics, postgraduates, and undergraduate students were identified for this study. Their overall views were analyzed and reported in Table 5 and Figure 4, illustrating an overall summary.

Table 5

Overall Participation of Genders in Engineering Mathematics

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Female	4	25.0	25.0	25.0
	Male	12	75.0	75.0	100.0
	Total	16	100.0	100.0	

It is evident that there were more male (12, 75%) than female (4, 25%) engineering academic and students who participated in this study which aimed to find out the frequency and levels of participation in the teaching and learning of engineering mathematics subject, particularly topics like antenna theory and engineering design. These results show that there is a low participation of females in learning and teaching the subject of engineering mathematics. Figure 4 validates these findings by presenting the frequency of gender participation in teaching and learning engineering mathematics.



1 Represent Female Gender; 2 Represent Male Gender

Figure 4: Overall Participation of Genders in Engineering Mathematics.

Qualitative Analysis

From the qualitative point of view, this study collected the perception, opinion and views of all participants regarding teaching and learning of engineering mathematics

subject, particularly antenna theory and engineering design courses, in the department of electronics engineering at a university in South Africa. This section analyzes the transcripts of the interviews with regard to the second research question: *What are the views of engineering academics and students when teaching and learning engineering mathematics?* There was a total of 16 participants comprising both students and academics (faculty). There were (04) engineering academics teaching prerequisite mathematics courses particularly antenna theory and engineering design courses; (03) postgraduates' students pursuing their master's program in engineering mathematics; and (09) undergraduate students, who were pursuing mathematics education at the elementary level.

All participants were given codes like: AC2 was the only female academic; PG1 was the only female postgraduate student; and G1 and G3 were the two female undergraduate students. Under the broad research question, the participants were probed with some secondary questions like what engineering-related mathematics courses had they taught or learnt. The only female academics AC2 reported that she integrates engineering mathematics into her teaching of engineering related courses. The PG 1 (female) student reported the adoption of some mathematical concepts such as "Calculus Differentiation, Integration, Geometry and Logarithm" in her studies. The undergraduate student G 1 (female), however, made a very positive statement, which reflects her interest in this subject of engineering mathematics:

I have already completed two modules which I understand to be related to this module, specifically on microwave engineering: Field Theory and EM Theory. These specific mathematics modules aided me to opt for a few more modules: Mathematics 1A, Mathematics 1B, Mathematics 2A, Mathematics 2B and Mathematics 3A.

The undergraduate participant, G3 (male) made a similar statement and elaborated on the process of learning and their involvement in learning this subject:

I find that all mathematics modules, Mathematics 1A, 1B, 2A, 2B and 3A have some link, mostly in calculations. Firstly, we learn modules like integration and geometry and apply them in mathematics through formulas /equations. in subjects like antennas theory, we apply potential function equations, transformed to spherical unit vectors using the transformation matrix, Equivalent circuit in transmitting Mode, we also learn basic circuit from physics.

These opinions of female participants clearly indicate that AC2 teaches engineering related mathematics in her university as an engineering academics, while PG1, G1 and G3 are engineering female students who integrate some mathematics concepts while learning mathematics related courses.

The male participants of the study also reported similar statements: AC 1 (male academic), for instance, reiterated:

If you are talking about mathematical modelling.....because there are mathematics modules they offered already either differential equation or whatever. Just for more mathematical modelling courses to be taken so that they can have more understanding on mathematical way of modelling things just like I told you earlier that there are courses on mathematical modelling.

AC3 (male academic) added an argument that:

Calculus, Differentiation, Matrices, Vector, Taylor expansion, Complex number Application of integration, Laplace transform, Linear ODE'S and Eigen value are common mathematics concepts that are being adopted when teaching engineering mathematics courses.

AC4 (male academic) reported that: *"We use design analytical equations to design the antenna for a particular frequency"*. This implies that the dimensions of the antenna are calculated using design equations. In addition, postgraduate students also shared their views. PG2, a male postgraduate engineering student, confessed that he adopted and liked subjects like *"Engineering statistics, Matrices, and Engineering mathematics ... because they (subjects) do teach us some part but there are so many types of mathematical modelling they didn't teach me the one I needed..."* G1, a male undergraduate student reported that: *"I have already completed two modules which I understand to be related to this module [mathematics]"*. G2, another undergraduate male student shared, *"Had already encountered many of the things discussed in this module in previous math modules, Electromagnetic theory, Field theory, Math 2A, Math 2B."*

Another undergraduate student, G3, argued that: *"all mathematics modules, have some links.... Yes, mostly in calculations."* G4, another undergraduate reiterated this statement:

We completed some math courses, and found that mathematics deal with various coordinate system i.e spherical, rectangle, etc. Also, calculus theories help with certain derivatives in the course. These helped us with basic understanding like coordinates, transformation to different coordinate system such as polar, spherical, and rectangular, and theory of calculus.

Similar views were expressed by G5 (undergraduate students): *"Yes, I have done field theory, calculus and physics before this module that involved all the mathematics theories that the module entails"*. He also reported that subjects like Physics, Calculus, Field theory, and Optics have mathematical applications but he did not learn subjects like antenna theory and engineering design earlier. Another undergraduate student, G6, confirmed this statement: *"Yes, concepts in previous Engineering Math Modules have helped my understanding such as vector calculus, gradient, divergence and curl operations."* He also reported some major courses of prerequisite mathematics courses such as Math131, Math141, Math238, Math248, Math354, which helped him understand how antennas are designed on coordinate systems as many of the formulae used in calculation are in spherical coordinates.

G7, an undergraduate student. Narrated in similar fashion: *"I have done field theory, calculus and physics before this module that involves all the mathematics theory in this module. Coupled with Calculus, Fourier Transform."* Similarly, G8, an undergraduate male student, suggests that Mathematical applications previously done in 2nd year (Math 238 and Math 248) play an important role in understanding coordinate systems (cylindrical etc.) and curl divergent matrices. G9, a male undergraduate students also added:

Yes, I have done all the Engineering Mathematics modules Math which helped me understands coordinate systems as well as curl and divergent matrices, including some prerequisites like Math131, Math132, Math141, Math142, Math238, Math248, Math3A and Math360.

Discussion

The results of the study made evident that females have a low participation in the process of teaching and learning of engineering mathematics in a university in South Africa, although the study cannot be generalized due to its small sample size, but the fact remains that there is a low intake of female students in the department of engineering mathematics in South Africa. This could be due to several factors, including psychological, socio-economic, cognitive, and poor problem-solving skills. Gender motivation and

professional driven skill are factors that can allow the continuity of females to study engineering mathematics subjects. The study found that the extent of gender participation in teaching and learning of engineering mathematics could be linked to parental influence on students (Mejía-Rodríguez et al., 2021).

The findings of the study suggest that a significant number of participants applied their mathematical expertise to their engineering mathematics studies. Eleven male participants model their mathematics when it comes to teaching and learning of an engineering-related mathematics. This is supported by the findings of Lubienski and Pinheiro (2020), who found that if gender disparities persist in the teaching and learning of mathematics, the low participation of female gender may continue in the department of engineering. On this point, a few participants stated that even in the engineering department, the teaching and learning of subjects like antennas theory can benefit students with strong mathematical foundation. Geyi (2023) corroborated this view and stated that one should never undervalue the difficult nature of engineering mathematics, which includes coordinate geometry and matrices, among many others. As a result, it is evident from the data gathered from the perspectives of the participants that there are not enough female academics, nor postgraduate and undergraduate students, in the domain of engineering mathematics due to its difficult nature.

The views expressed by the participants hint at the fact teaching and learning of engineering mathematics demonstrate that, despite the complex nature of engineering mathematics, academic and students were actively involved in the process of teaching and learning some. This suggests that gender participation in teaching and learning of engineering mathematics is influenced by factors like the nature of the mathematics to be applied, the availability of a problem-solving skills, gender occupational motivation, which is applicable to both practicing engineers and students for better productivity self-esteem, and psychology model. Figure 5 is an attempt to suggest a gender participatory model to increase the participation of women in engineering mathematics at university levels based on these factors.

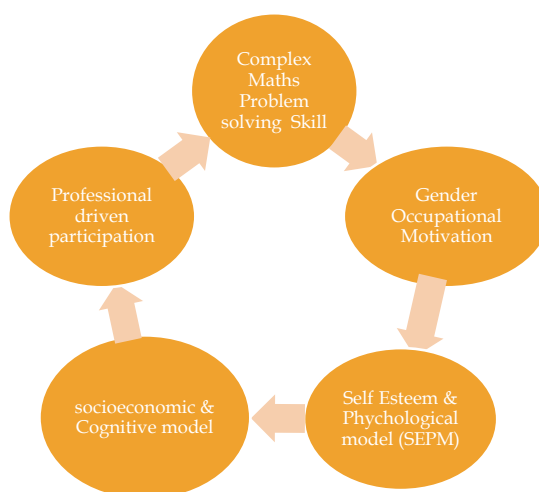


Figure 5: Gender Participatory Model in Engineering Mathematics.

In addition to this, when taking about the participation of males and females in engineering-related courses, particularly in engineering mathematics, the impact of the socioeconomic status cannot be ignored. One could also argue that the female's involvement in engineering education can be improved by professional motivation from private sector. All these concepts carefully assist the process of gender participation of engineering students in engineering mathematics.

Conclusion, Implications and Recommendations

The participation and views engineering academics and students about gender participation in the process of teaching and learning engineering mathematics has been a thing of concern. This study confirmed that the involvement of females in teaching and learning of engineering mathematics-related courses in an engineering context has been low. In fact, the study discovered that at a university in South Africa, there is a very low female participation in both teaching and learning of engineering mathematics. This implies that if care is not taken, the involvement of women in engineering courses, in particular engineering mathematics, may affect female engineering professionals within and outside the country. On this note, this study confirmed the need to improve female enrolment in engineering mathematics in order to increase female participation in engineering education. Furthermore, findings also confirmed that females have little knowledge of mathematical ideas compared to their male counterparts. In view of this, more encouragement and motivation should be given to female engineering mathematics academics and students to increase their academic output. However, cultural background cannot be toyed with, but the fact remains that mathematically related courses should not be religion or culturally based courses. Therefore, having the content knowledge is not enough, but developing a mind that can prevail in any form of anxiety, boldness, and all other socioeconomic backgrounds may be of assistance to female students in achieving more in engineering mathematics.

A shortage of human resources among engineering academics, students and experts has been a thing of serious concern, and the outcome of this study coupled with other available literature indicate that some of the universities in South Africa have been battling with the shortage of female engineering experts teaching and learning engineering mathematics. This shortage has affected the number of females in the field of engineering. Therefore, to change this common narrative, a few suggested may be given such as : introduction of a coding camp programs and workshops to inspire women by showcasing the possibilities within science and mathematics education; more efforts should be made to increase the visibility of female role modelling mathematical concepts in engineering education; additionally, there should be a public-private partnership in promoting the opportunities for women in the fields of engineering mathematics. These recommendations if well implemented could assist the students, regardless of their gender, to succeed and thrive in the field of engineering mathematics.

Conflict of Interest

The authors declare that the research was conducted in the absence of any financial assistance. Therefore, no conflict of interest.

Acknowledgement

The authors acknowledge the participants that contributed to this study.

Funding

The authors did not receive any financial assistance for this study.

Data Availability Statement

Data will only be available on request due to confidentiality issues.

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