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Research Article

Students' Failure in Mathematics: A Case Study of Calculus-Related Modules at a University in Johannesburg

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Abstract

Mathematics is widely recognized as a challenging subject for many students, often leading to high failure rates among university learners. This study investigates the factors contributing to student failure in two calculus-related mathematics modules at a university in Johannesburg, South Africa. Five key factors are examined: students' attitudes toward mathematics, self-doubt, teaching methods employed by lecturers, access to textbooks and learning materials, and short attention spans. Data were collected through a Google Form questionnaire distributed to students, and the findings were analysed using statistical methods. The results indicate that neither age nor gender significantly affects students' performance in mathematics. However, the five identified factors play a substantial role in determining success or failure. These findings are supported by a Chi-Square test, yielding a statistically significant p-value of 0.000128. We also provide some valuable insights from the polarity and subjectivity analyses of the students' responses. While the insights provided are valuable, this study acknowledges that these factors represent only part of a broader set of influences on student outcomes in mathematics.

Keywords: Mathematics performance; Calculus-related modules; Student failure factors; Teaching methods

INTRODUCTION

Mathematics as a popular subject or module has been reported by most students to be one of the most di cult subject or module at high school and university level. At the university level, students doing engineering and science courses will have to take one or more Mathematics modules before they can complete their degree. While some students pass these modules once, others must fail it one or two times before they pass it. This seems to be the story of many students worldwide [1-12]. Hence, the need for more research in this area. As a Mathematics Lecturer, I was privileged to teach some calculus-related modules in one of the universities at the city of Johannesburg, South Africa. Calculus-related modules

are modules consisting of entirely differentiation and its application and/or integration and its application topics. These modules are taken by students doing engineering and science courses.

Research Objectives

The following are the objectives of this study:

1. To explore reasons for students' failure in calculus-related and/or Mathematics-related modules.
2. To recommend possible solutions to students who are registered or who will be registering for calculus-related or Mathematics-related module(s) on how to avoid failure in such the module(s).
3. To give hope of success to students (in any field) who have failed any Mathematics- related modules as they embark on taking the module(s) again.
4. To emphasize to lecturers teaching Mathematics-related module(s) the importance of good teaching methods for students to get motivated in studying and to succeed in Mathematics module.

It is the hope of the researcher of this study that the results of this paper will assist many students to get out of the pit of failure in their calculus-related modules and to succeed in their Mathematics Modules, in general, at the university level. Also, we believe that this study will contribute to the existing body of knowledge in the research on why students fail mathematics as a subject/module in their universities.

Research Hypotheses

The following are the research hypotheses of this study.

H_0: The age of the students does not contribute to the students' failure in Mathematics.

H_1: The age of the students does contribute to the students' failure in Mathematics.

H_0: The gender of the students does not contribute to the students' failure in Mathematics.

H_1: The gender of the students does contribute to the students' failure in Mathematics.

H_0: The following factors – Accessibility to textbooks and materials; Attitude towards Mathematics; Method of teaching by the Lecturer; Self-doubt; Short Attention Span - do not contribute to the students' failure in Mathematics.

H_1: The following factors – Accessibility to textbooks and materials; Attitude towards Mathematics; Method of teaching by the Lecturer; Self-doubt; Short Attention Span - do contribute to the students' failure in Mathematics.

LITERATURE REVIEW

There are several factors that contribute to mathematics failure in the university among students. We shall not try to give a comprehensive list of them, but we shall mention some

of them. In [1], the author identified and explained the factors that contribute to the failure rate in mathematics courses at Visayas State University (VSU). The paper provided a structured questionnaire to measure students' perception of learning mathematics and their perception of a mathematics teacher. The study revealed that poor study habits (51%), negative learning attitudes (22.5%), social environment (13.9%), emotional problems (7.3%), and financial problems (5.3%) are the main factors affecting the failure rate in mathematics at VSU. The author in [13] identified the systemic failure in math education despite attempts at reforming curricula and pedagogy. He Highlighted the widening gap between high school mathematics and college expectations, leading to difficulties for students. The author also pointed out the disconnect between how mathematics subject is taught in school and how professionals in fields like science, engineering, and mathematics use mathematics. The study criticized the use of clumsy examples that require strong reading comprehension skills instead of focusing on mathematical reasoning and it challenged the pedagogical approach of offloading arithmetic to calculators and substituting algebra instruction, arguing that it is not effective.

In [14], the author identified the high failure rate of students in mathematics and attributed it to poor teaching methods and negative attitudes of teachers, which restrict students' freedom to communicate. It was highlighted that this failure rate is higher for hearing-impaired students. The study explored various methods of teaching mathematics and factors that can either improve or hinder their success. It emphasized the importance of teachers having a positive attitude towards students, a good mastery of the subject matter, and a deep understanding of students' needs and capabilities. In [15], the authors suggested the inclusion of mathematical resilience, which has not been considered in university mathematics education before, to investigate dropout in freshmen. The study presented a novel instrument to measure mathematical resilience against mathematics exercises and provide evidence of its validity and reliability through an empirical study with 424 mathematics freshmen. The study explored the challenges specific to the study of mathematics that freshmen need to overcome to avoid dropout. It contributed to the understanding of the emotional challenges faced by freshmen in mathematics studies and highlights the importance of mathematical resilience in overcoming these challenges. In [16, 17], the authors aimed to determine how student mathematics anxiety affects student mathematics achievement. The study used the Mathematics Anxiety Rating Scale questionnaire (A-MARS) for assessing mathematics anxiety and found a negative linear correlation ($r = -0.479$, $p < 0.05$) between mathematics anxiety and mathematical performance, indicating that mathematics anxiety negatively affects students' mathematical performance. That is, higher levels of mathematics anxiety are associated with lower mathematical achievement.

In [16], the authors observed that the tertiary transition from secondary school to university is challenging for many students, including those enrolled in the mathematics degree. The study pointed out that students considered "gifted" in mathematics in their secondary school often struggle with failure in the subject in their universities and have difficulty interpreting their failures initially. Hence, the study tried to investigate the role of

emotions in the emergence and management of the tertiary crisis period for mathematics students and how their view of mathematics and self-perception develop during this period. In [10], the authors aimed to investigate the causes of poor academic performance in Mathematical Methods I among undergraduate students in Obafemi Awolowo University, Nigeria. Data was collected through a questionnaire distributed to three hundred respondents. Descriptive statistics, such as frequency counts and percentage distributions, were used to analyse the obtained data. From the study, factors such as poor infrastructure, emotional problems, and weakness in mathematics background were identified as contributors to poor performance. The study also tried to determine the factors that determine students' success or otherwise in the course MATH201 - a second-year module in the same university. It was observed that a significant percentage of students who sat for the examination received grades below average, indicating poor performance. The attitudes of students towards low academic performance were observed and it was highlighted that students often attribute their low performance to external factors and feel bad about it. The study recommended re-medial counselling involving cognitive restructuring and achievement motivation to improve performance.

We summarize the following from the literature. Firstly, the students' lack of interest in mathematics can greatly contribute to their failure in the subject [18]. The fear of mathematics and negative attitudes towards the subject can also have a significant impact on the students' performance in mathematics [1, 17, 19, 20]. Secondly, the failure to comprehend directions and weak understanding of mathematical concepts are also significant contributors to mathematics failure in the university. Motivational factors and self-efficacy also play a role in student performance in mathematics. Students' own expectations, goal setting, and self-efficacy have been found to have correlations with student performance in mathematics modules at the tertiary level [21]. Students who have confidence in their ability to perform mathematical tasks successfully tend to have better mathematical performance [15, 21].

Thirdly, emotions can play a crucial role in the crisis experienced by mathematics students during the tertiary transition, affecting their view of mathematics and self-perception [16]. Thus, emotional problems, financial problems and economic issues can also contribute to failure in mathematics [1, 11, 16]. Lastly, teaching methods have a significant impact on mathematics failure. The poor methods of teaching employed by mathematics teachers/lecturers and negative attitudes of teachers/lecturers restrict students' freedom to communicate and it contributes to negative feelings towards mathematics [14]. Another reason is the disconnect between how mathematics is taught in school and how it is used in real-world applications, leading to a lack of relevance, and understanding to the students [13]. Also, teachers' inability to teach for understanding which could help students' ability to develop personal mathematical meanings could contribute to failure in mathematics [10].

QUESTIONNAIRE DATASET

In collecting the data for this study, we explore the use of google form for the questionnaire which contains eight (8) items - gender, age and six questions as shown in

Table 1. Items 3 – 8 was then renamed as Question 1 -6 as shown in Table 2. The total number of responses received from the questionnaire is 90, and it represents the number of respondents. These numbers are students who have done calculus-related modules before in the university either as their first time or more. Hence, the data consists of 90 rows and 8 columns. Since the study requires human participation in its data collection, there is a need for ethical clearance, which was granted by the ethics committee at the university where this study was conducted. Hence, the researcher has been granted permission to use the obtained data for research purposes.

Table 1. Items Listed in the Questionnaire

Items	Title	Expected Answers
1	Gender	male/female
2	Age	18-21yrs / 22-26yrs / 27-31yrs / 32 -36yrs
3	Did you fail this module before?	yes / no
4	How many times have you fail this module?	1 / 2 / 3
5	What factor(s) do you think make you fail?	Accessibility to textbooks and Materials/ Attitude towards Mathematics / Method of teaching by the Lecturer / Self Doubt / Short Attention Span
6	Did you now pass the module?	yes / no
7	What factor(s) helped you pass the module?	Accessibility to textbooks and Materials/ Changed of attitude towards Mathematics/ Method of teaching by the Lecturer / Self Confidence / Long Attention Span
8	What would be your recommendation to a new student who wants to pass this module?	Comments from the students

Table 2. List of Renamed Questionnaire Questions

Items	Title in the Questionnaire	Renamed Title
3	Did you fail this module before?	Question 1
4	How many times have you fail this module?	Question 2
5	What factor(s) do you think make you fail?	Question 3
6	Did you now pass the module?	Question 4
7	What factor(s) helped you pass the module?	Question 5
8	What would be your recommendation to a new student who wants to pass this module?	Question 6

ANALYSIS AND RESULTS

Equation numbers should appear in parentheses and be numbered consecutively. Python language was used to do the analysis in this study. And the following are the libraries used numpy, pandas, matplotlib, wordCloud, nltk, textblob, seaborn and spaCy. The configuration of the computer system used is a follows: Intel(R) Core(TM) i5-7300U CPU @2.60GHz, 8.00GB of RAM, 64-bit Window 10 Enterprise operating system. Using pandas library in jupyter notebook, we can view the responses of the questionnaires that were downloaded in .csv format in a nice format on dataframe. Figures 1 gives an overview of the dataset obtained from the questionnaire.

	Gender	Age	Did you fail this module before?	How many times have you fail this module?	What factor(s) do you think make you fail?\n(You can check more than one)	Did you NOW pass the module?	What Factor(s) helped you pass the module?\n(You can check more than one)	What would be your recommendation to a new students who wants to pass this module?
0	Female	18 - 21 yrs	Yes	1	Attitude towards Mathematics;Method of Teachin...	Yes	Change of my attitude towards Mathematics;Meth...	To always do their tutorials and attend all cl...
1	Female	18 - 21 yrs	Yes	1	Attitude towards Mathematics;Method of Teachin...	Yes	Change of my attitude towards Mathematics;Meth...	Always be ahead of the lecture, practice mathe...
2	Female	18 - 21 yrs	Yes	1	Short Attention Span	Yes	Change of my attitude towards Mathematics;Meth...	Attend all the lectures and make sure you comp...
3	Female	18 - 21 yrs	Yes	1	Method of Teaching by the Lecturer	Yes	Method of Teaching by the Lecturer	Always make sure you are ahead of the lecture ...
4	Male	18 - 21 yrs	Yes	3	Self Doubt	Yes	Change of my attitude towards Mathematics;Meth...	NaN

Figure 1. Items contained in the Questionnaire

Figure 2 shows that there are more male students doing calculus-related module(s) than the female students. The percentage of male students is 56.2% while that of the female students is 43.8%. This maybe because the modules are for engineering, physics, computer science students and there are more males than females in this area of study.

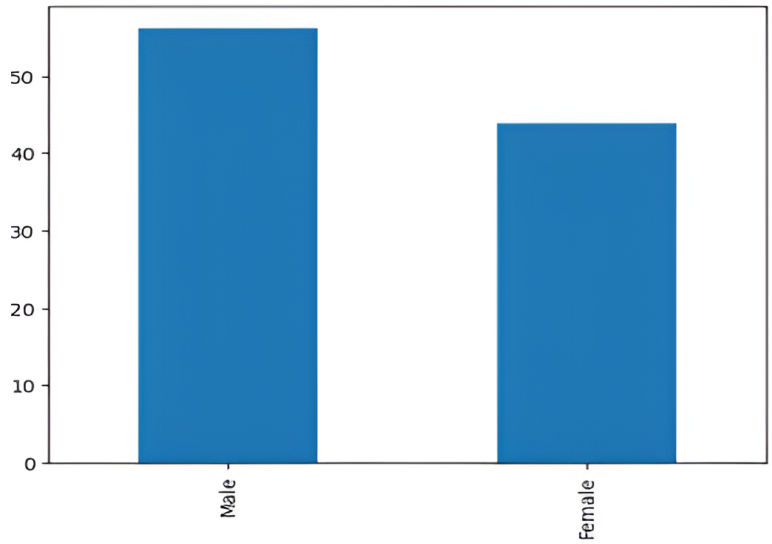

Figure 2. The Gender Count of Students Who did the Module (in percentage)

Analysis of the Data

Figure 3 shows the number of students who have failed calculus-related module before and those who have not. About 71.1% of the students who filled in the questionnaire said they have failed calculus-related modules before, while the remaining 28.9% have not failed before.

Having established that most students have failed calculus-related module(s) before, we now want to know the number of times these students have failed the module(s) before. Figure 4 depicts the number of times these students have failed calculus-related module(s).

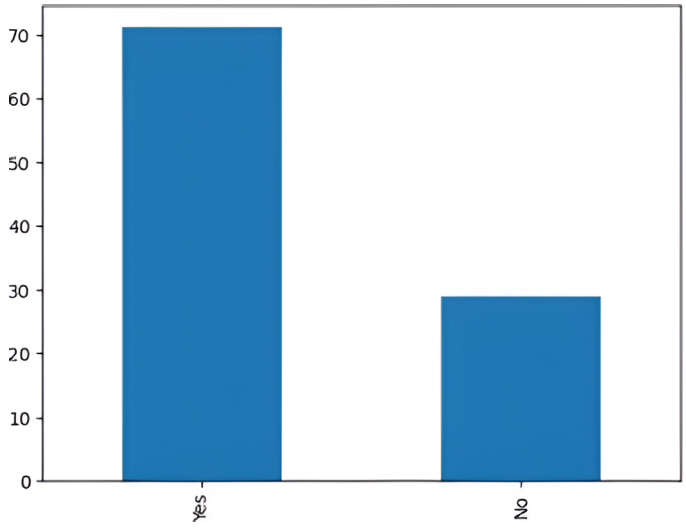

Figure 3. The Percentage Number of Students Who had Failed the Module Before and Those Who Have not.

From the figure, about 91.1% of the students have failed calculus-related module(s) once, while 5.6% have failed the module(s) two (2) times, and 3.3% have failed the module(s) three (3) times before.

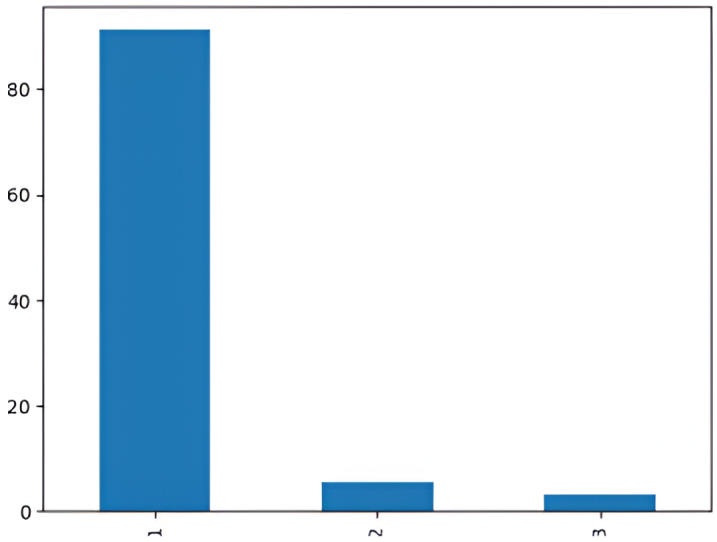

Figure 4. The Number of Times the Students Failed the Module (in percentage)

This shows that the majority of those who have failed calculus-related module(s) before are those who have failed it one time. This should be expected because most students learn their lessons of seriousness in a subject or module like mathematics after failing the first time. However, it is surprising when such students fail the module(s) the second and/or third time as it could be seen in Figure 4. About 8.9% of the students have failed the module at least two (2) times. There could be some factors responsible for this failure and we shall be glad to investigate these factors in future research.

To give some hope to students who have failed calculus-related module(s) before and all students doing mathematics-related modules, we present the result of students who have now passed the module(s). Figure 5 shows the number of students who now pass their calculus-related module(s). About 97.8% of the students who filled in the questionnaire did pass the module(s) while only 2.2% failed the module(s). This serves as an encouragement to all students doing calculus-related module(s) that they can still succeed in such module(s) despite any past failure.

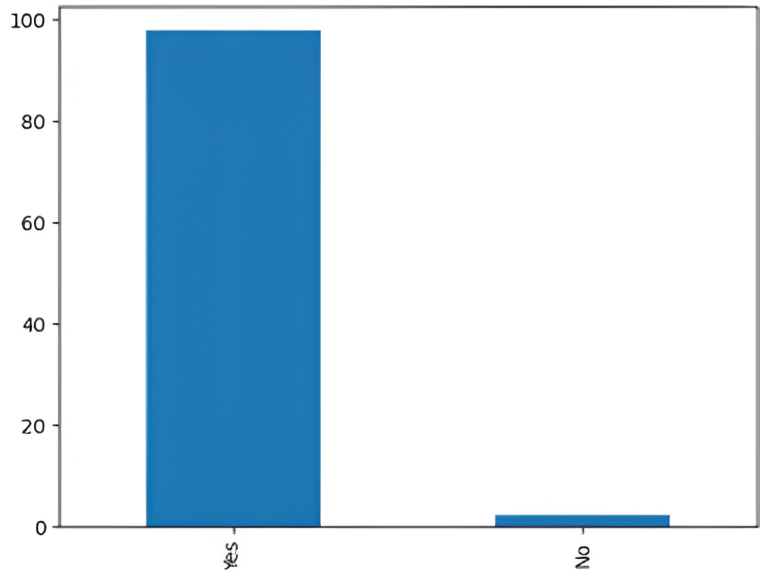

Figure 5. The Number of Students that now Pass the Module (in percentage)

To know the factors that contributed to the student's failure, Question 3 was inserted into the questionnaire. Figure 6 shows the factors the students think contributed to their failure in the module(s). The percentage of each of the factors are as follows. self-doubts (27.6%), method of teaching by the lecturer (25.2%), attitude towards mathematics (23.6%), short attention span (18.9%), and accessibility to textbooks and materials (4.7%). Hence, the top two (3) factors causing the failure of most students doing calculus-related modules are self-doubt, method of teaching by the lecturer and attitude towards mathematics. This means that if any student is to succeed in their calculus-related modules, such students must work on their self-doubt. Each student must develop an "I can do" attitude towards mathematics.

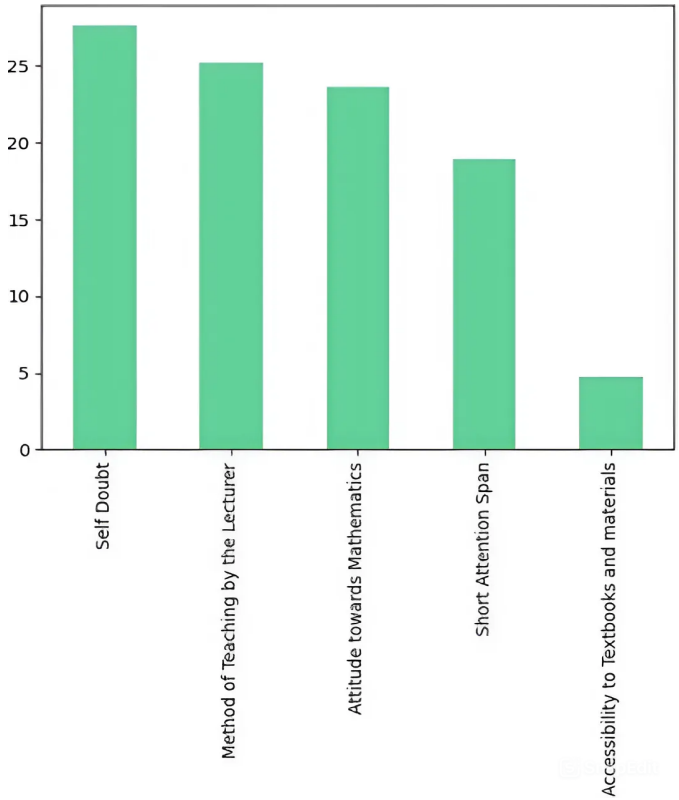

Figure 6. Factors Causing the Students' Failure in the Module

The next factors to consider are the factors that helped them to succeed in their calculus-related module(s). Figure 7 depicts the factors enhancing the students success in the module(s). The percentage of each factor is as follows. Method of teaching by the lecturer (33.3%), change of my attitude towards mathematics (24.8%), self-confidence (22.9%), long attention span (10.5%), and accessibility of textbooks or materials (8.5%). The three (3) top factors are the method of teaching by the lecturer, self-confidence and change of attitude towards mathematics.

Most students attest to the fact that accessibility to lecture materials and textbooks is not their problems. Self-confidence and a change of attitude towards mathematics mod- ules are needed for any student to succeed. Therefore, we encourage all students doing calculus-related and/or mathematics-related modules to ensure they change their attitude and develop their self-confidence towards mathematics. This same encouragement was also given in [4]. Students' resilience in coping with mathematics exercises has been found to be relevant in the context of university mathematics studies [15].

We can observe from the figure that although the method of teaching by the lecturer may not be the top cause of failure for most students, it is however, the top-most factor that help students to succeed in calculus-related modules and by extension mathematics-related modules. Hence, the need to encourage all lecturers teaching mathematics-related modules to ensure they use strategies that will motivate the students interests in understanding,

studying and succeeding in such modules. This need for encouragement goes along with the recommendation of the author in [4] that teachers should conduct assessments on the students they are teaching to decide on the teaching methods that can help the students to perform better. On a side note, we believe part of what a lecturer teaching mathematics should do is to stir up the morale of their students towards learning mathematics. It is essential to recognize that motivation plays a significant role in students' success in mathematics [22]. Studies have shown that motivation is the most influential factor related to the level of success in mathematics.

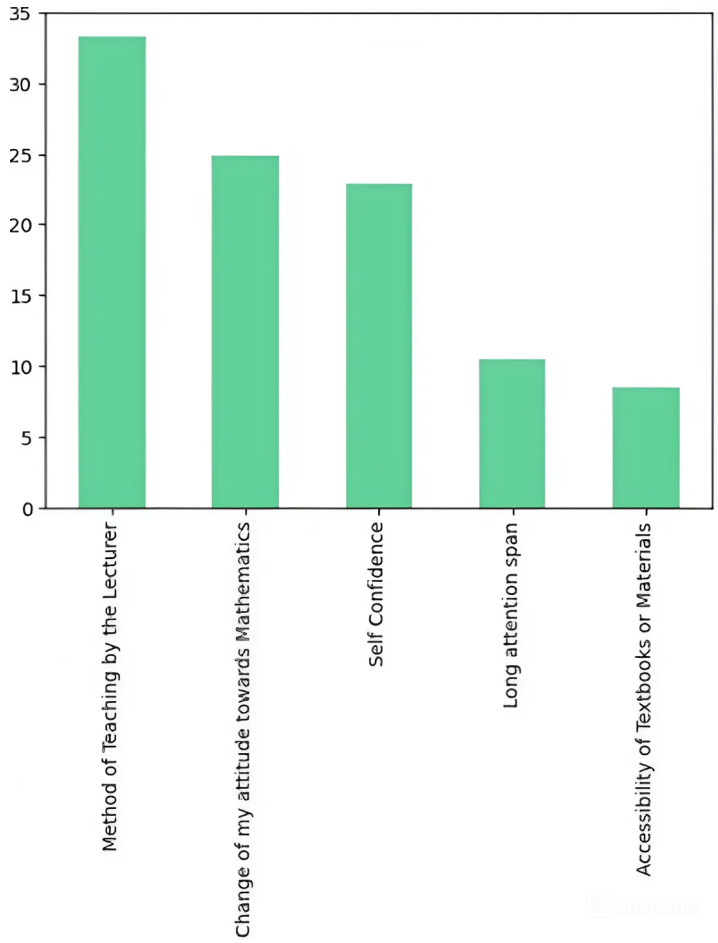

Figure 7. Factors Enhancing Students' Success in the Module

Statistical Analysis

We perform a Chi-Square Test to determine whether to accept the null hypotheses or reject it. The test was performed to know whether there is statistically significant relationship between a student passing or failing the module and gender, age, or the five factors mentioned above. The following results are shown in Tables 3 until 5.

Table 3. Gender Versus Passing/Failing the Module

Chi-Square Statistic: 0.294371
p-value: 0.587432
Degrees of Freedom: 1

Table 4. Age Versus Passing/Failing the Module

Chi-Square Statistic: 1.065463
p-value: 0.785417
Degrees of Freedom: 3

Table 5. The Factors Versus Passing/Failing the Module

Chi-Square Statistic: 51.647727
p-value: 0.000128
Degrees of Freedom: 20

Table 3 shows the result of Gender versus passing/failing the module. It is observed that the value for the Chi-Square statistics is very small, and the p-value is 0.587432. This is greater than 0.005. Hence, we shall accept the null hypothesis which says that the gender of the students does not contribute to the students' failure in Mathematics.

Table 4 shows the result of Age versus passing/failing the module. The Chi-square statistics is also very small, and the p-value is 0.785417. This is also greater than 0.005. Hence, we accept the null hypothesis for this also. The null hypothesis states that the age of the students does not contribute to the students' failure in Mathematics.

In Table 5, we obtain the result for the five factors identified in this study versus the passing/failing the module. The Chi-square value is large, and the p-value is 0.000128, which is less than 0.005. Hence, we shall reject the null hypothesis and accept the alternative hypothesis. That is, the following factors – Accessibility to textbooks and materials; Attitude towards Mathematics; Method of teaching by the Lecturer; Self-doubt; Short Attention Span - do contribute to the students' failure in Mathematics.

Analysis of the Students' Recommendations

We use python libraries to show the frequency of the words used in the recommendation of the students. The bigger the word, the more frequent it was used. This is called a word cloud. It is also known as text cloud or tag cloud. It is a collection of keyword words depicted in different sizes [23-25]. The more a word appears in the collection, the bigger and bolder it shows in the word cloud [23-25]. Figure 8 depicts the word cloud of the comments given by the students as asked in Question 6 of the questionnaire. We can observe from the figure that words like "practice", "tutorial", "always", "time", "work", "help", "ask", "study",

"everyday", "module", "math", "question", "never", "questions", "lecture", "understand", "attend", "class", "day", "make", "hard", "sure" and "give" came out boldly.

Firstly, we present the students' recommendation from the answer given in Question 6 ("What would be your recommendation to a new student who wants to pass this module?") in the questionnaire. Figures 9 and 10 depicts the advice given by students who had failed the module before but now have passed the module. TextBlob, a free and open-source library in Python, was used for the analysis of this textual data [26, 27]. The library allows us to determine whether the input textual data has a positive, negative, or neutral tone. It returns a sentiment tuple (polarity, subjectivity) for the input textual data. The polarity score is within the range $-1.0 \leq$ polarity ≤ 1.0, where -1.0 being strongly negative and 1.0 being strongly positive. Also, the subjectivity score is within the range $0.0 \leq$ subjectivity ≤ 1.0, where 0.0 is strongly objective and 1.0 is strongly subjective [26, 27].

The comments at Figure 9 are classified as positive because the polarity values are greater than zero. The highest subjectivity value is 1.000000 for the comment with an index of 43, while the lowest subjectivity value is 0.500000 for the comment with indexes of 22, 32, 36, 39 and 17. Furthermore, the comments in Figure 10 are classified as negative because the polarity values are less than zero. The highest subjectivity value is 0.700000 for the comment with an index of 25. While the lowest subjectivity value is 0.250000 for the comment with an index of 12. The titles used in the questionnaire for Questions 1, 4, and 6 can be seen in Table 2 as mentioned before. The indication of "Yes" for both Questions 1 and 4 in Figures 9 and 10 shows that these students have failed the module(s) before and they have now passed the module(s). Hence, their comments are highly important and any student who wants to pass any calculus-related module(s) should read and follow these recommendations.

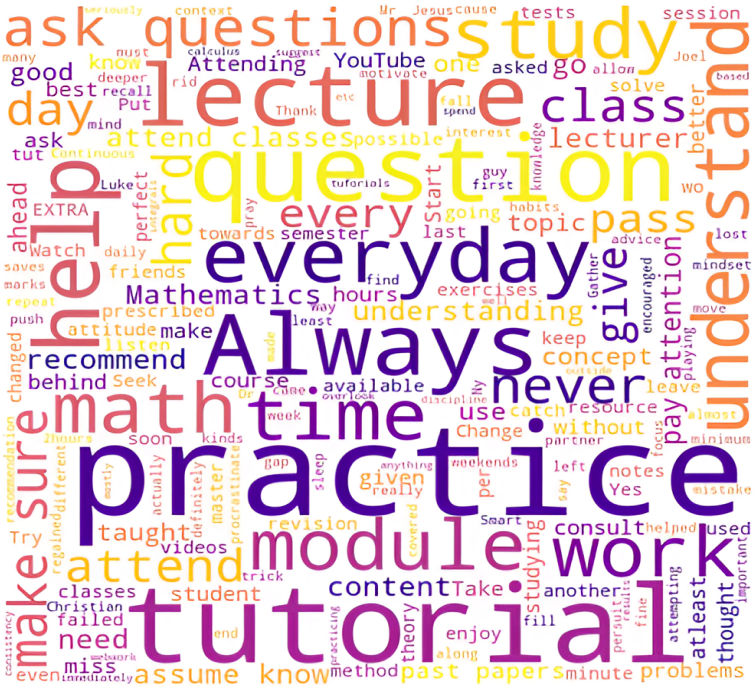

Figure 8. A Word Cloud of the Students Recommendation

	Question 6	Gender	Question 1	Question 4	polarity	subjectivity
43	Practice makes perfect.	Female	Yes	Yes	1.000000	1.000000
22	Change their attitude towards mathematics and practice more	Female	Yes	Yes	0.500000	0.500000
32	I suggest that they should start immediately practicing integrals because that is what calculus is mostly based on	Male	Yes	Yes	0.500000	0.500000
36	Just keep trying. It gets better.	Female	Yes	Yes	0.500000	0.500000
39	practice more, never miss a lecture/tutorial, use Youtube and provided slides/textbook to practice	Male	No	Yes	0.500000	0.500000
51	Always be ahead of the lecture, practice mathematics every night before sleeping. Have love and passion for it.	Female	Yes	Yes	0.500000	0.600000
53	Always make sure you are ahead of the lecture regarding your school work	Female	Yes	Yes	0.500000	0.888889
68	Change your attitude and believe in yourself and most importantly invest your all in this module	Female	Yes	Yes	0.450000	0.750000
17	Don't assume you know ask questions and find a way to enjoy doing your work.	Female	Yes	Yes	0.400000	0.500000
57	Practise by doing questions everyday. Start studying from day one because practising makes perfect.	Female	Yes	Yes	0.400000	0.800000

Figure 9. Students' Comments with Positive Polarity Values

	Question 6	Gender	Question 1	Question 4	polarity	subjectivity
25	Ny recommendation would be for students to focus and pay attention from the get go, and not to fall behind because in the persuit of playing catch up, you miss out on on the context of the content and you end up not understanding it at all.	Male	Yes	Yes	-0.400000	0.700000
13	Study hard and practice the math then you will pass	Male	No	Yes	-0.291667	0.541667
41	Pay attention to lecture classes and work hard everytime	Female	No	Yes	-0.291667	0.541667
8	Practice every topic that is covered that week at least once a day, and do past papers on weekends. That is what helped me pass the module.	Male	No	Yes	-0.275000	0.325000
12	Past papers to practice with	Male	Yes	Yes	-0.250000	0.250000
40	Practice everyday! Give yourself 2 hours of maths each day.	Male	No	Yes	-0.250000	0.600000
15	Listen to your lectures, ask all questions you have in your mind... practice all exercises given per session and don't be left behind cause you won't fill the gap. Always give yourself minimum of 2hours per day and practice/study maths	Male	Yes	Yes	-0.200000	0.350000
56	Dedicate atleast 2 hours everyday to study Mathematics Mathematics needs a lot of practice sothat you understand every concept	Female	Yes	Yes	-0.200000	0.600000
65	I would recommend them to get assistance from other students who understand as soon as possible if they have any challenges on this module . Because once you are behind you will never catch up . I would also recommend them to do all the tutorial questions	Female	Yes	Yes	-0.175000	0.691667
11	Have a study partner so you can motivate and push each other.	Male	Yes	Yes	-0.125000	0.375000

Figure 10. Students' Comments with Negative Polarity Values

Polarity Distribution

The polarity scores indicate the sentiment (negative, neutral, or positive) of the students' comments. We shall analysis this with the Figures 11 and 12. In Figure 11, most of the

comments have a positive polarity (ranging from 0.4 to 1.0), meaning that students provide motivational, constructive, and encouraging feedback. The highest polarity (1.0) is for "Practice makes perfect," showing a strongly positive and universally accepted statement. Most comments cluster around 0.4 to 0.5, indicating that students express positive sentiments without extreme enthusiasm, focusing on practical advice rather than exaggerated optimism. While in Figure 12, most of the comments have a negative polarity (between -0.4 and -0.1), confirming that this dataset contains mostly constructive criticism or dissatisfaction. The most negative comment has a polarity of -0.4, indicating a strong negative sentiment. A few comments are closer to neutral (around -0.1), meaning they are slightly negative but not extremely critical. The fact that the scores are mostly mild negative rather than extreme negativity (-1.0) suggests that the students are providing critical but constructive feedback rather than outright complaints.

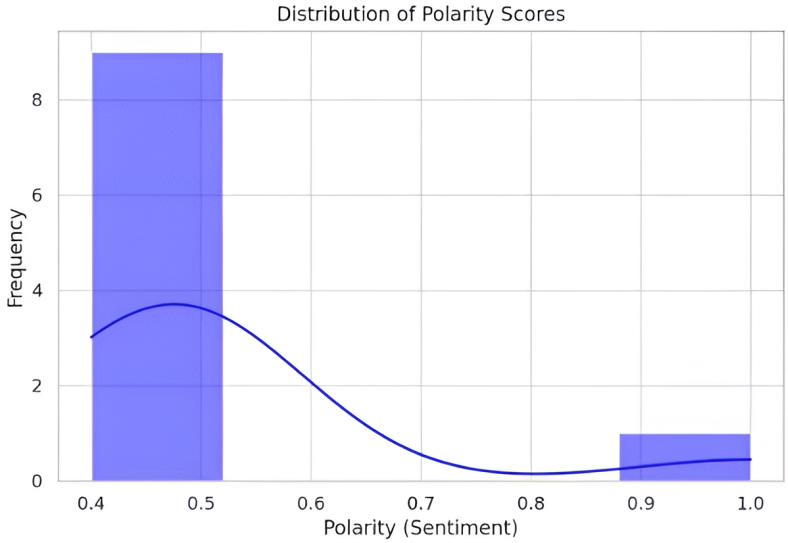

Figure 11. Polarity Distribution for the Positive Comments of the Students

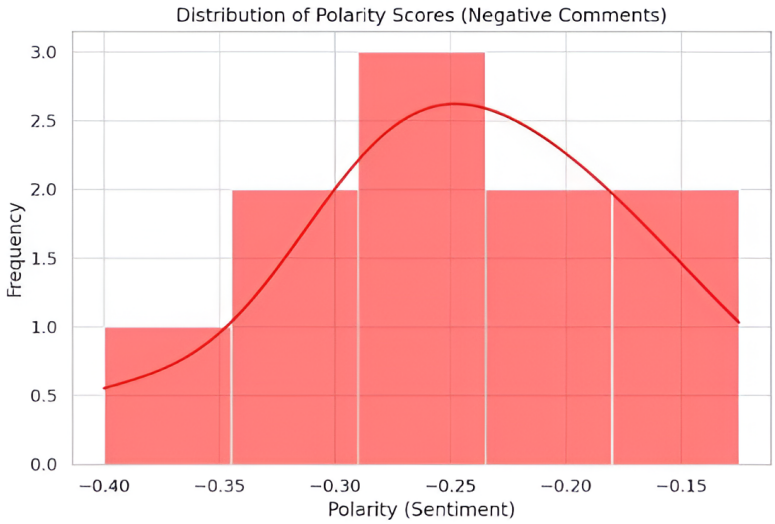

Figure 12. Polarity Distribution for the Negative Comments of the Students

Subjectivity Distribution

The subjectivity scores from the students' comments show how opinionated the comments are. We shall also give some analysis of this in Figures 13 and 14. For the distribution in Figure 13, the subjectivity scores range from 0.5 to 1.0, meaning that most comments are highly opinionated rather than purely factual. Some highly subjective comments (close to 1.0) are statements like *"Practice makes perfect."* These are personal beliefs or motivational phrases that do not rely on factual evidence but serve as inspiration. Comments with moderate subjectivity (0.5 - 0.7), such as *"Change your attitude and believe in yourself"*, mix personal motivation with actionable advice. This suggests that students offer positive encouragement based on personal experience rather than strict academic strategies.

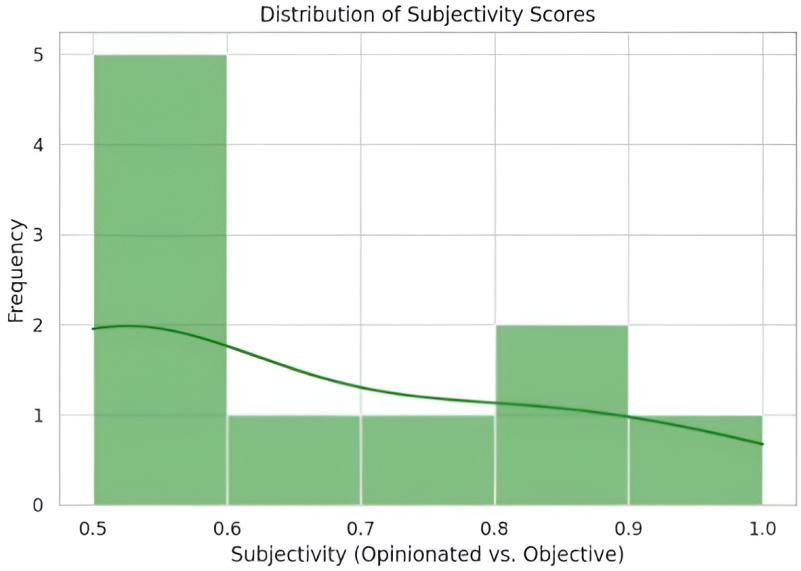

Figure 13. Subjectivity Distribution for the Positive Comments of the Students

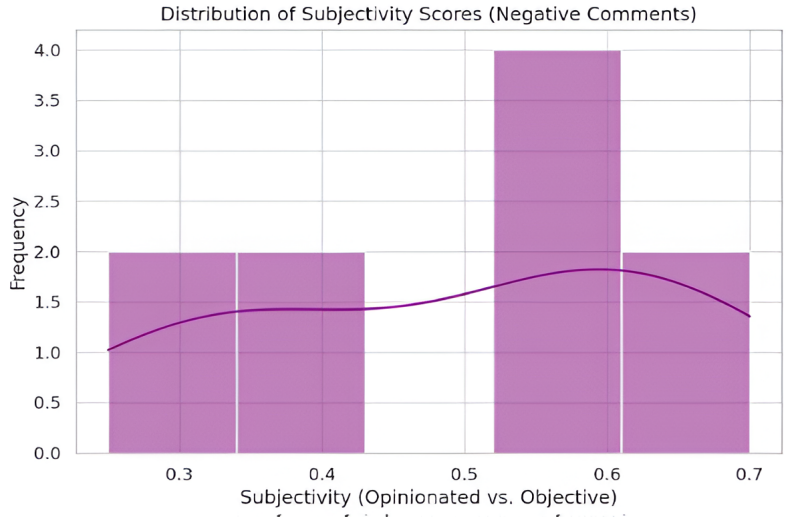

Figure 14. Subjectivity Distribution for the Negative Comments of the Students

While in Figure 14, most comments have subjectivity scores between 0.3 and 0.7, meaning they contain both facts and opinions. Some comments are highly subjective (close to 1.0), meaning they are mostly personal opinions rather than factual statements. Example: *"My recommendation would be for students to focus and pay attention from the get-go..."* (subjectivity: 0.7). Others have low subjectivity (close to 0.2-0.3), meaning they are more objective and fact-based. Example: *"Past papers to practice with."* (subjectivity: 0.25). This suggests that students provided a mix of personal experiences and factual study advice, making the feedback diverse and informative.

Gender-Based Sentiment Comparison

In this section, we shall analyse the female and male sentiment trends and provide a boxplot for some insight. We present this analysis in Figure 15 and 16. For the boxplot in Figure 15, most comments are from female students, who seem to express positivity more frequently. Males also contribute positive feedback but appear in fewer instances. The females use more encouraging and inspirational language. While the male, since their polarity scores cluster closer to 0.5, use more balanced comments rather than extremely positive.

In Figure 16, both male and female students provided negative feedback, but there may be differences in intensity and style of expression as observed from the boxplot. The female comments have a higher median polarity (closer to 0), which shows that they are slightly less negative than male comments. The males have a wider range of polarity scores, which implies that they are expressing more extreme criticism compared to females.

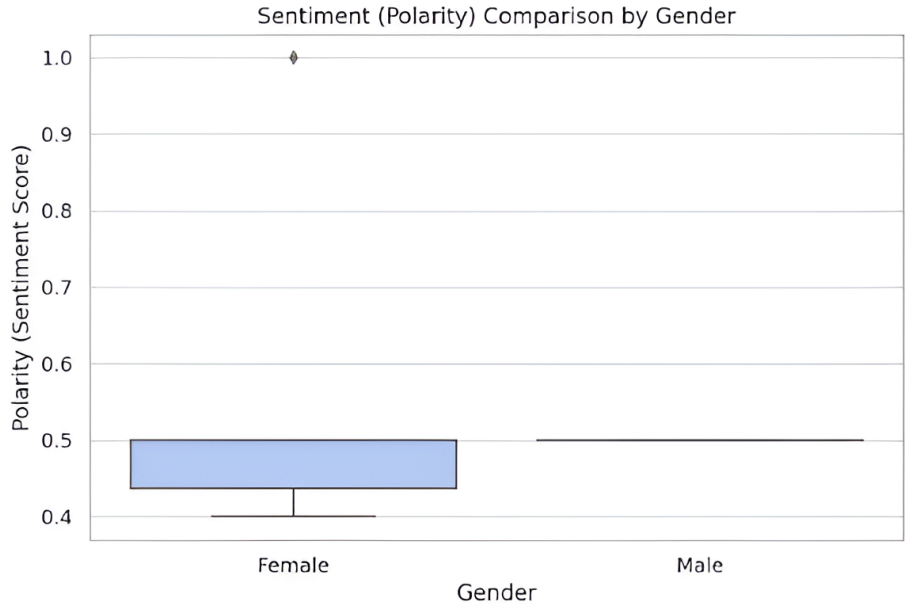

Figure 15. Boxplot for the Positive Comments of the Gender-Based Sentiment

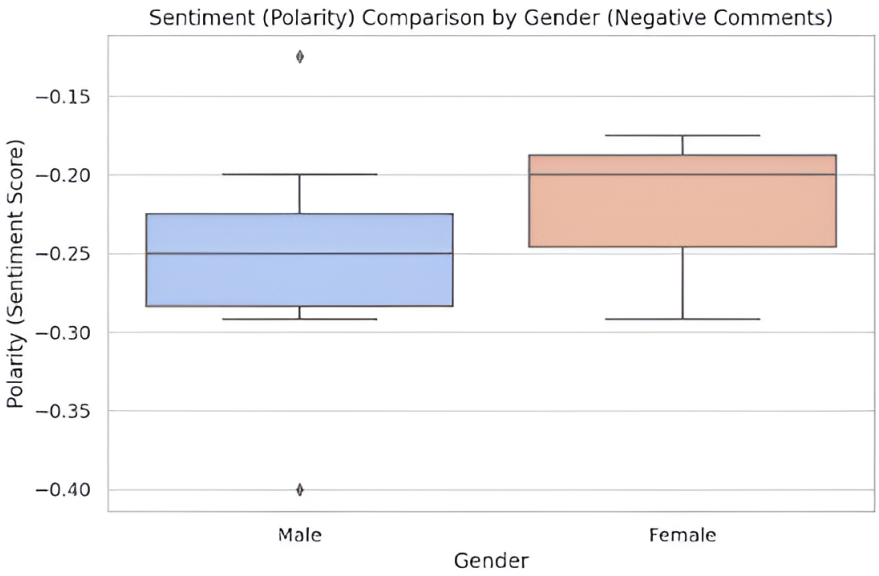

Figure 16. Boxplot for the Negative Comments of the Gender-Based Sentiment

CONCLUSION

In conclusion, the study highlights the multifaceted nature of student performance in mathematics, particularly in calculus-related modules at a university in Johannesburg. The findings underscore that while factors such as age and gender do not play a significant role in determining success or failure, critical elements such as attitude towards mathematics, self-doubt, teaching methods, resource accessibility, and attention span are significant contributors. These factors, supported by statistical evidence (with a p-value = 0.000128), suggest that addressing students' perceptions, enhancing teaching strategies, and improving access to resources could collectively bolster academic outcomes in mathematics.

Recurring theme from both the positive and negative comments include following:

1. Comments on repetition and daily practice (*"Practicing every day will help you succeed."*).
2. Emphasis on changing one's mindset (*"Believe in yourself and invest in your studies."*).
3. Comments on being proactive and preparing early (*"Always be ahead of the lecture."*).
4. Highlights on the importance of engaging in class and seeking help from classmates or tutors to avoid confusion.
5. Some mentions of YouTube, past papers, tutorial exercises and textbooks as learning aids.
6. A common complaint is that students who do not focus enough during lectures, fall behind.

This study recognizes that the causes of failure in mathematics are broader than the five factors analysed, hence, the limitation of this study. This indicates the need for further research to explore additional influences. By addressing these issues holistically,

universities can create a more supportive learning environment, ultimately improving student success rates in mathematics.

CONFLICT OF INTERESTS

There is no conflict of interest associated with this publication.

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