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EFFECTS OF REMEDIAL TEACHING ON THE PERFORMANCE OF PRE-SERVICE TEACHERS IN CALCULUS IN THE EDUCATION COLLEGES IN GHANA

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Abstract

Calculus is one of the highest intellectual achievements globally and is a major way for pre-service teachers to move into the fields that will empower the economy of the 21st century. However, more than 30% of students in Ghanaian tertiary education institutions fail calculus courses each year. This is vital for mathematics educators to improve the success of students and find ways to increase calculus achievement by pre-service teachers. This study aimed to investigate the performance of basic pre-service mathematics teachers in calculus in colleges of education in Ghana. Furthermore, the study assessed gender differences in the performance of basic education pre-service teachers in calculus. The researcher used a short case study design. Purposive sampling was used to select 92 (72 males and 20 females) pre-service teachers from 493. Findings indicate that preservice teachers performed well in calculus. Although the study indicates no significant difference between the performance of male and female pre-service teachers in calculus, the male pre-service teachers outperformed their female counterparts. The study concludes that the use of remedial teaching can enhance the academic performance of pre-service mathematics teachers in calculus. The study recommends that mathematics teachers allocate more time for teaching and learning calculus at the college level.

1. Introduction

Most pre-service teachers have difficulty understanding concepts in calculus (Toh et al., 2022; Toh et al., 2021). Some of these difficulties could be due to the transition from elementary to advanced mathematics, which makes a move from showing to proving in a logical order based on the definition. Calculus is a branch of mathematics

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that deals with rates and change. Thompson and Dreyfus (2017) described calculus as a constant rate of linear variation. Calculus is useful in various ways.

Calculus serves as the foundation for science, technology, engineering, and mathematics (STEM) education (Sebsibe & Feza, 2020). Furthermore, it helps to investigate how stars, particles, and matter move and change in real-time. Calculus is one of the major components of mathematics in Ghana's colleges of education curriculum. It is also a precursor for learning algebra, geometry, and ordinary differential equations. Future teachers, doctors, scientists, engineers, and mathematicians study concepts in calculus, and a course in calculus promotes intellectual achievement by citizens globally (Rasmussen et al., 2014). According to Vestal et al. (2015), a strong foundation in calculus must earn a degree in engineering.

Despite the numerous advantages of calculus, many studies have indicated that pre-service mathematics teachers (PMTs) have difficulty understanding concepts in calculus. The average failure rate in the United States (US) calculus courses is more than 25% (Dawkins & Epperson, 2014). According to Treisman (1992), as cited in McKinney and Dibbs (2021), an average of 600,000 first-year college students take calculus, and out of this, 250,000 (41.7%) students fail every year.

Leng and Ming (2017) investigated the effects of a flipped classroom model on the performance of university undergraduate students in calculus. This study used a quasi-experimental design. Participants were tested using a calculus test. The results indicate that students in the experimental group scored significantly higher on the calculus test than their counterparts in the control group. The researcher agrees because using the flipped classroom model to learn calculus can help students understand concepts in calculus. Similarly, Usman et al. (2020) assessed Indonesian calculus learning beliefs and university students' understanding of the limit of functions. The results showed that students who had high beliefs in calculus learning could solve the limit of function problems by principle, concept, and procedure. Self-confidence facilitates high academic achievement.

Toh et al. (2022) evaluated the understanding of school calculus among PMTs in Singapore. A set of PMTs was given a calculus instrument that assessed their iconic thinking, algorithmic thinking, and formal thinking on numerous school calculus subjects. The study findings show that, apart from their strong performance in iconic recognition of stationary points, they had relatively poor recognition of points of inflexion, differentiability, and the concept of minimal points. This could be due to inadequate time allocated for teaching and learning the subject. As a result, PMTs lack conceptual understanding of the subject. Similarly, Likwambe and Naidoo (2018) investigated the knowledge of pre-service teachers in South African secondary schools on calculus. The study reported that pre-service teachers struggle with calculus. This could be attributed to the advanced nature of calculus and the inability of some mathematics teachers to complete the curriculum for calculus. Studies indicate that approximately 30% of mathematics teachers are unable to complete the calculus curriculum (García-García & Dolores-Flores, 2021).

However, relatively little is reported regarding the performance of pre-service teachers in calculus in Ghana's colleges of education. Most of the research conducted has been focused on university students. Additionally, studies conducted across the world investigated the performance of pre-service teachers in calculus using strategies, including the flipped classroom model and Maple software. This paper attempted to bridge that gap by investigating whether remedial teaching could have an effect on pre-service teachers' performance in calculus in Ghana's colleges of education. Furthermore, this study investigated gender differences in the academic performance of participants in calculus.

2. Statement of the problem

Calculus is a strand of mathematics. Calculus is a basic subject in the Colleges of Education that should be studied by students in the Department of Mathematics and Information Communication Technology Education because

it is used in other more complex subjects. Calculus is not only studied by students in the mathematics department but also in other departments, such as the science and engineering departments, that are linked with mathematics. Calculus is a vital and fundamental subject for pre-service mathematics teachers. It is also a precursor for students to understand the concepts of geometry, algebra, and ordinary differential equations.

However, a lack of pre-service teachers' knowledge of calculus might cause them to not understand concepts in other mathematics strands. The 2020 national report in Ghana has shown that the performance of pre-service teachers in calculus was low compared to other mathematics courses. Furthermore, international studies indicate that PMTs perceive calculus concepts as abstract and conceptually challenging, leading to low academic performance in the subject. This implies that more needs to be done to improve the academic performance of students in the subject. This study attempted to intervene in this situation by using remedial teaching in the teaching and learning of calculus.

In Ghana, not much research has been conducted on describing PMTs' low academic performance in calculus in the colleges of education. To bridge this gap, this study investigated the academic performance of PMTs in calculus at the college level. Therefore, this study aimed to investigate the effects of remedial teaching on the academic performance of basic PMTs in calculus, and by gender, in the colleges of education in Ghana.

3. Research Objectives

These objectives guided the study:

a) To assess the academic performance of PMTs in calculus.

b) To investigate gender differences in the performance of PMTs in calculus.

4. Hypothesis

This study tested the following hypothesis:

H0: There is no statistically significant gender difference in academic calculus performance among PMTs in Ghana's colleges of education.

5. Literature Review

This section outlines the reviewed literature contribution under the performance of PMTs in calculus. The literature review was based on the following research objectives: (1) PMTs' academic performance in calculus and (2) gender differences in academic performance in calculus. The themes were discussed in the following order:

Students' previous knowledge of mathematics influences their success in subsequent courses. Students struggling in calculus may lack algebra and trigonometry skills (Vestal et al., 2015), as cited in McKinney and Dibbs (2021). Another study suggests that knowledge of algebra is necessary for university classes, and a lack of knowledge in pre-calculus concepts could cause a large number of students to fail in calculus (Dawkins & Epperson, 2014).

Globally, McKinney and Dibbs (2021) investigated the performance of university students in calculus in the United States. According to them, over 25% of students fail U.S. calculus courses each year and change majors in Science, Technology, Engineering, and Mathematics. I am not surprised at the findings because a strong foundation in calculus is needed to be successful in trigonometry, geometry, and differential equations. This failure in calculus could be due to the lack of knowledge in geometry, trigonometry, algebra, and differential equations. Mathematics teachers should improve students' success and try to enhance their calculus achievement (McKinney & Dibbs, 2021). Similarly, Dawkins and Epperson (2014) investigated the interactions between problem-solving and learning calculus among secondary PMTs in the United States. The results indicate that the top-performing students exhibited better calculus skills and algebraic fluency than their counterparts. Furthermore, students who withdrew from calculus frequently displayed a lack of algebraic fluency and graphical interpretation understanding. This means that knowledge of algebra is a prerequisite for learning calculus. As

Kindle and Gentimis (2018) found, algebra is fundamental for learning calculus. However, these studies were conducted abroad. The focus of this study was Ghana.

Tatira (2021) investigated secondary school PMTs' construction of the application of first-order differential equations (DE) using task-based interviews in Africa. The findings indicate that only a few PMTs could understand the application of DEs. Students perceive calculus as abstract and difficult to understand. According to the Mathematical Association of America (the USA, n.d.), 25% of students in the United States of America fail calculus on average (https://compscicentral.com/is-calculus-hard/, retrieved on 8th July 2022). This implies that students need adequate comprehension of the process and objects, which might enhance higher-order thinking skills in their preparation to teach in secondary school. However, the study was conducted in South Africa. The focus of this study was Ghana.

Additionally, Machromah et al. (2019) conducted a study on university students' learning calculus with GeoGebra. The study reported that over 50% of the students gave a positive response to using GeoGebra in the teaching and learning of calculus. GeoGebra enhanced students' understanding of concepts in calculus. This could be because GeoGebra motivated students to learn integral calculus. As indicated by Yimer and Feza (2019), GeoGebra is a mathematical software that promotes mathematics teaching and learning. However, the study targeted university students. The focus of this study is on college of education students.

In Ghana, Emmanuel et al. (2021) investigated the effectiveness of applying Maple software at the Evangelical Presbyterian College of Education to reduce PMT errors in integral calculus. The findings indicate that PMTs committed many technical, conceptual, and procedural errors when solving integral calculus tasks. Furthermore, the results indicate that the PMTs in the experimental group outperformed their counterparts in the control group. This shows that the Maple software is an instructional aid that assists students in the experimental group in understanding integral calculus concepts. Maple software promotes the teaching and learning of calculus. This agrees with Saparwadi et al. (2019), who used Maple software to study reversible thinking ability in calculus learning. The study reported that Maple software is more suitable for teaching and learning calculus for students in mathematics education. Emmanuel et al. focused on PMTs' performance in the integration concept. However, the focus of the present study is on the calculus performance of PMTs in general.

In conclusion, PMTs perceive calculus as a difficult subject to understand. This could be because calculus is at a slightly higher conceptual level than pre-calculus and high school algebra. Students need to put in more effort to practice tasks regarding calculus concepts.

The following section discusses the literature review of gender-based PMTs' performance in calculus. Kotsopoulos et al. (2021) investigated whether the use of guided notes (GN) could support the learning of calculus among Canadian university students. The study reported that GN improved calculus achievement among students in the experimental group compared with their counterparts in the control group. The results further indicate that there were no significant interactions between gender and GN. It makes sense to state that learning calculus with guided notes does not affect gender. In contrast, Isiksal (2015) conducted a study on gender differences in calculus achievement. Findings indicate a statistically significant difference between gender achievement in calculus. Female PMTs outperformed their male counterparts in calculus achievement. However, these studies were conducted on PMTs at universities. The focus of this study is on PMTs in colleges of education.

In Africa, Misu et al. (2018) assessed the metacognition profile of mathematics PMTs in understanding concepts of calculus concerning gender. Findings indicate a difference in the metacognition profile between female and male mathematics PMTs in the comprehension of concepts concerning integral calculus in the interpretation category. Male PMTs outperformed their female counterparts. The researcher is not surprised at the result because people have the perception that mathematics is only for men. Wade et al. (2017) investigated high school

preparation for college calculus and found that calculus is a male-dominated domain. This study focused on university PMTs. The new angle for this study is on PMTs in Ghana's College of Education.

Arhin and Offoe (2015) investigated gender differences in mathematics academic performance among senior high school students in Ghana using performance assessment-driven instruction. The results indicate that there was no statistically significant difference in academic performance in mathematics between male and female students. Indirectly, the performance assessment-driven instruction in the teaching and learning of mathematics provided an equal platform for both male and female students in terms of mathematics achievement. It makes sense to state that mathematics is for everyone. Schnell and Prediger (2017) assessed the mathematical potential of economically exploited students in Germany and reported that all students are capable of learning mathematics regardless of gender. In contrast, Zutaah et al. (2022) investigated gender performance of college PMTs in geometry and reported that male PMTs outperformed their female counterparts in geometry concepts. In Ghana, few studies have been conducted to describe the performance of college of education PMTs in calculus concerning gender. This study aimed to bridge this gap by investigating gender differences among PMTs' academic performance in calculus at the country's college level of education.

It makes sense to conclude that all PMTs are capable of learning calculus, irrespective of gender, provided that all students are given equal platforms in terms of academic performance in calculus and mathematics in general.

6.1 Methodology

This study used a quasi-experimental design. Specifically, one short case study design was used. In this design, an experimental treatment is administered to a group, and then a post-test is administered to test the treatment's effects (Mugenda & Mugenda, 2019). This design involves only one group, and there is no pre-test. In this design, the use of remedial teaching in the teaching and learning of calculus is the independent variable, whereas the academic performance of PMTs in calculus is the dependent variable. This study was conducted on basic PMTs in the Presbyterian College of Education (PCE), Akropong Akuapem, Ghana. This is justified by the fact that students in the PCE are a homogeneous group, and it is applicable elsewhere. Also, PCE was selected as the study location because it is a science college and students in the college study calculus. This study targeted all first-year preservice teachers in the PCE. The target population of the study is made up of 493 first-year PMTs, of whom 313 are males and 180 are females.

6.2 Sampling procedure and sample size

Purposive sampling was used to select all 92 PMTs who studied calculus in the first year. This is because calculus is an elective subject that is not offered to all college students. The sample was made up of 72 males and 20 females. The sample size for this study is representative because Cohen et al. (2011) indicated that an experimental study should have at least 15 participants. The study excluded students who had completed a general program. Students in the general program do not study calculus in college. The composition of the sample is summarized in Figure 1.

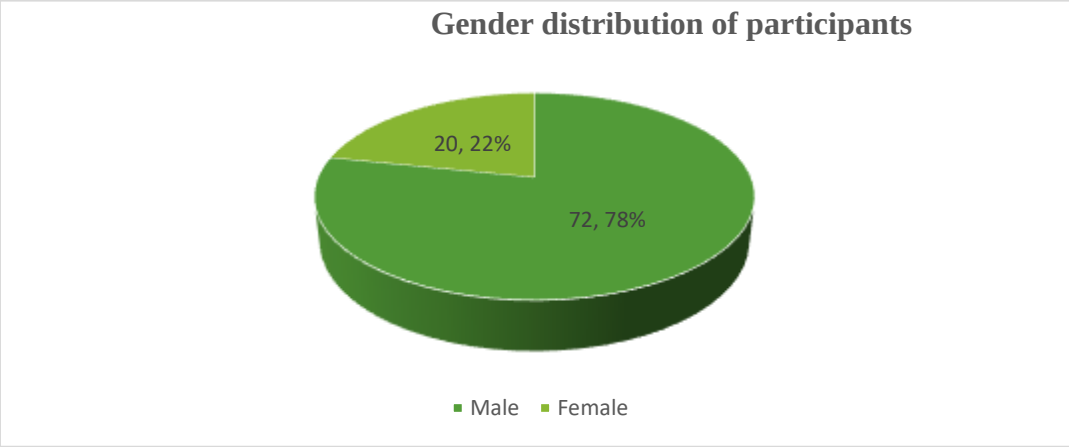

Figure 1 Sample composition

Figure 1 indicates that the study sample size included 78% males and 22% females. Calculus achievement test was used as a tool for data collection. The researcher sought permission from the principal of the college to conduct the study in this institution. See Appendix 'A' for the research permit. Data were collected using a calculus achievement test conducted by the researcher for first-year PMTs in the second semester of the academic year. This is because calculus is a first-year second-semester course for the college's mathematics, science, agricultural science, and technical students. At the beginning of the study, all the students were given remedial teaching and learning of calculus for 14 weeks. The researcher taught the participants using remedial teaching and the calculus curriculum for 14 weeks. Remedial teaching included weekend and after-school teaching. At the end of the intervention, all students took the end-of-semester examination as the post-test. See Appendix 'B' for the grading system and interpretation of the grades used in Ghana's colleges of education. The study recorded the results of PMTs' second-semester calculus grades and analyzed the results.

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25. Descriptive statistics, such as frequencies, percentages, mean, and standard deviation, were used to analyze the academic performance of the PMTs in calculus in response to research question one (1). Inferential statistics, such as the independent samples t-test, were used to analyze gender differences in the academic performance of PMTs in calculus to respond to research objective two (2). The t-value was calculated at a significance level (p-value) of $p \leq 0.05$ (2-tailed) at a 95% confidence interval (CI) with a margin of ± 5.

7.1 Results and Discussion

In this section, the results are presented as follows. (i) PMTs of basic school academic performance in calculus. (ii) Gender differences among PMTs' performance in calculus. Finally, this study tested the null hypothesis: **H0:** There is no statistically significant gender difference in calculus achievement among PMTs in Ghana's colleges of education. Table 1 presents the demographic information of the PMTs.

Table 1: Demographic analysis

Sex	N	Percentage
Male	72	78.3
Female	20	21.7
Total	92	100.0

An examination of Table 1 indicates that 72 PMTs are males, representing 78.3%. On the other hand, 20 pre-service teachers are females, representing 21.7%. Females are less than males by 56.6%.

7.2 Research Objective 1: To investigate the academic performance of PMTs in calculus

This study sought to investigate the academic performance of PMTs in calculus. This was done to help the researcher gain in-depth information regarding the academic performance of the participants in calculus. Table 2 presents the academic performance of the PMTs in calculus.

Table 2: Academic performance of PMTs in calculus

Grade	N	Percentage
D	4	4.3
D+	4	4.3
C	9	9.8
C+	17	18.5
B	14	15.2
B+	10	10.9
A	34	37.0
Total	92	100.0

Table 2 presents the calculation academic performance analysis of the first-year students' PMTs at the end of the second semester of the academic year. The results indicate that approximately half (34 out of 92) of the PMTs scored grade ''A'' (scores from 80% to 100%). This means that approximately half of the students scored marks ranging from 80% to 100%. These students did not struggle with answering the problems related to calculus. Furthermore, 24 PMTs representing 26.1% scored grades ''B and B+" (scores from 70% to 79%). These students scored marks ranging from 70% to 79%. Furthermore, more than one-quarter of the pre-service teachers, representing 28.3%, scored grades "C and C+" (scores from 60% to 69%). This revealed that 28.3% of the PMTs scored marks ranging from 60% to 69%. Finally, only one-tenth of the pre-service teachers, representing 8.6%, scored "D and D+" (scores from 50% to 59%). This means that only 8.6% of the PMTs scored marks ranging from 50% to 59%. Table 2 shows that no student scored below 50%. Students who scored below 50% are considered failures in the examination. Otherwise, the pass mark is 50%. Therefore, all students who took the calculus achievement test passed. This implies that all the students who learned calculus using the remedial method passed the calculus achievement test. The remedial teaching helped the teacher and learners cover the calculus curriculum. The teacher also had enough time to explain concepts to the learners for conceptual understanding.

In this study, the calculus performance of PMTs is good. The implication is that the remedial teaching approach enabled the researcher to complete the calculus curriculum with participants, which led to their understanding of calculus concepts. As Özüdoğru and Aksu (2020) have convincingly shown in their work, PMTs who learned calculus using flipped learning achieved significantly higher achievement test scores and final grades compared with the traditional instruction group. Indirectly, the flipped learning approach enabled participants to understand calculus concepts. Participants in this study were taught calculus for 14 weeks. The researcher introduced remedial teaching to ensure students' understanding of calculus concepts and the completion of the calculus curriculum. The remedial teaching helped PMTs get more time to learn and understand calculus concepts, which led to that remarkable performance.

Furthermore, the findings of this study are in agreement with those of Wahab et al. (2021). This study investigated the effects of learning integrals and their application using graphing calculators among PMTs. This study used a quasi-experimental design. The findings indicate a statistically significant difference in calculus achievement between the PMTs who learned integral calculus using the graphing calculator and those who did not. Indirectly,

the graphing calculator serves as a learning aid that makes calculus concepts clearer for students in the experimental group. The implication is that mathematics teachers should use technology applications and allocate more time for teaching and learning calculus. Students should also devote more time to learning calculus.

However, the findings of this study contrast with the findings of Wijaya and Asnawati (2018). Wijaya and Asnawati assessed PMTs' ability to solve concepts in calculus in Indonesia using Polya's steps. The results indicate that PMTs with low self-efficacy could not understand calculus concepts. This means that the participants were not able to solve the calculus problems. This could be because PMTs made mistakes in solving problems related to calculus. This implies that mathematics teachers should allocate more time to teaching and learning calculus to promote students' understanding of calculus concepts.

To conclude, the performance of pre-service teachers in calculus varies. The PMTs in this study demonstrated remarkable performance in calculus. Students are capable of achieving high scores in calculus. Mathematics teachers should allocate more time to teaching and learning calculus.

7.3 Research objective 2: To investigate gender differences in the performance of PMTs in calculus

In assessing research object 2, the researcher examined gender differences among basic PMTs' academic performance in calculus. The gender-related performance of PMTs in calculus was presented as follows:

a) Performance of the PMT in calculus regarding gender using frequencies and percentages
b) Comparative analysis of the gender performance of PMTs in calculus using mean and standard deviation.
c) Gender differences in the performance of PMTs in calculus using the Independent Samples T-Test

Furthermore, this study tested the following null hypothesis: **H0:** There is no statistically significant gender difference in calculus performance among PMTs in Ghana's colleges of education.

7.3.1 Performance of PMT in calculus regarding gender using frequencies and percentages

This study assessed the performance of PMTs in calculus regarding gender using frequencies and percentages. The results are presented in Table 3.

Table 3: Gender * grade crosstabulation

Grade		D	D+	C	C+	B	B+	A	Total
Gender	Male	2	3	7	12	12	7	29	72
	Female	2	1	2	5	2	3	5	20
Total		4	4	9	17	14	10	34	92

Table 3 presents the analysis of gender-related PMTs' academic performance in calculus. The highest grade is A, and the lowest is D. An examination of Table 3 indicates that approximately one-half (29 out of 72) of the male PMTs scored grade 'A' (scores from 80% to 100%). This means that approximately one-half of the male participants scored above 79%. However, only one-quarter (5 out of 20) of their female counterparts scored grade A. Furthermore, more than one-third, representing approximately 26.4% of male pre-service teachers, scored grades 'B and B+' (scores from 70% to 79%), whereas only one-quarter (5%) of their female counterparts scored it. These students scored marks ranging from 70% to 79%. Similarly, 19 male participants, representing 26.4% scored grades 'C and C+" (scores from 60% to 69%), compared to 7 female participants, representing 29.2%. These students scored marks ranging from 60% to 69%. Five of the male participants (6.9%) scored grades (D and D+), whilst only 3 representing 15.0% of their female counterparts scored it. This means that these students scored between 49% and 60%.

Table 3 indicates that the performance of male PMTs in calculus is slightly higher than that of their female counterparts. This result shows that as many as 48 male PMTs scored grades 'A, B, and B+" (scores from 70% to 100%) and are described as above-average teachers compared with 10 of their female counterparts. These

teachers may be able to teach calculus well, specifically, and mathematics in general. Furthermore, 19 male participants scored grades (C and C+) and are described as average mathematics teachers, as compared to 7 female counterparts. These pre-service teachers are described as average mathematics teachers and may need little guidance to teach mathematics well. As indicated in Table 3, students who scored grades (D and D+) are considered below-average mathematics teachers. They may need assistance and guidance to manage mathematics lessons.

The findings of the present study are in line with those of Felson and Trudeau (2016), who investigated gender differences in mathematics achievement among students in grades 5–12 in the United States. The study reported that although girls scored higher in other subjects than boys, boys scored higher in mathematics than girls. Males are more likely to take advanced mathematics than their female counterparts. In summary, males are more likely to perform well in the calculation subjects than their female counterparts. Females are more likely to take advanced English courses.

Garba (2014) investigated the correlation between mathematics anxiety and calculus achievement among engineering students in Nigeria. This study's results show that the gender difference in calculus achievement is insignificant. Females display higher anxiety than males. This could be because females perceive calculus as an abstract form of advanced mathematics. Females perceive calculus as difficult, specific, and mathematics in general. This agrees with those of Ellis et al. (2016), who assessed the confidence in mathematics among male and female PMTs. The study found that females exhibit a greater lack of confidence in mathematics than their male counterparts. Mathematics teachers should provide equal opportunities for both males and females to learn calculus, specifically, and mathematics in general. This could minimize calculus anxiety among female PMTs. In conclusion, male PMTs scored higher in calculus than their female counterparts. Additionally, female students demonstrated higher anxiety in calculus than their male counterparts.

7.3.2 Comparative Analysis of the Gender Performance of PMTs in Calculus

The present study aimed to compare the academic performance of PMTs in calculus regarding gender. A comparative analysis was conducted using the mean, standard deviation, and standard error. The analysis was performed based on the grade points presented in Appendix B. As indicated in Appendix B, Grade A = 4, Grade B+ = 3.5, Grade B = 3, Grade C+ = 2.5, Grade C = 2, Grade D+ = 1.5, Grade D = 1, and Grade E = 0. The comparison is shown in Table 4.

Table 4: Comparison of the gender performance of PMTs in calculus

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Grade	Male	72	3.15	.871	.103
	Female	20	2.83	.990	.221

Table 4 presents a comparison of the academic performance of PMTs in calculus concerning gender. In an examination of Table 4, the GPA score of males is 3.15 (3.15 = Grade B+ = scores from 75% to 79%), and that of their female counterparts is 2.83 (2.83 = Grade C+ = scores from 65% to 69%). The GPA score of males is higher than that of females. This means that male pre-service teachers scored higher in calculus than their female counterparts. This could be because the male participants understood concepts in calculus more than their female counterparts when using a remedial teaching approach. The male participants demonstrated more interest in learning calculus than their female counterparts. Male participants' performance is better than that of their female colleagues. The findings of this study are similar to those of Antecol et al. (2015), who assessed the effect of teacher gender on mathematics achievement among primary school learners. The results indicated that male

students performed better in mathematics than their female counterparts. Although Antecol et al. focused on mathematics in general, the situation is not different in calculus among pre-service teachers in colleges of education. The study of mathematics by Antecol et al. included calculus concepts. Similarly, Zutaah et al. (2022) reported that male PMTs outperformed their female counterparts in geometry lessons using GeoGebra. Mathematics teachers should relate concepts in calculus to real-life situations to enable all learners to visualize the concepts of calculus. Female students should be encouraged to study the subject.

Table 4 indicates that the standard deviation of the males is 0.871 compared to 0.990 for the females. The standard deviation of females is higher than that of males. This shows that the female scores are more spread around the mean score than the male scores. It makes sense to state that male PMTs achieved higher calculus scores than their female counterparts. On the other hand, the mean standard error of the males in this study is 0.103, compared to the mean standard error of the females of 0.221. Comparatively, the mean standard error for females is higher than that of males. This means that the male PMTs are many more than the females and are more representative of the overall population than the females. In sum, male pre-service teachers performed better in calculus than their female counterparts.

7.3.3 Gender Differences in the performance of PMTs in calculus using the independent samples t-test

This study sought to investigate gender differences in the academic performance of PMTs in calculus. The comparison was performed using a p-value and a significance level of 0.05 at a 95% confidence level. The analysis was based on the GPA of students' achievement in calculus. The comparison is presented in Table 5.

Table 5: Gender difference in the performance of PMTs in calculus

Independent sample t-test

		Levene's test for equality of variances		t-test for equal means						
									95% confidence interval of the difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Grades scored by students	The equal variances assumed	.432	.513	1.445	90	.152	.328	.227	-.123	.778
	Equal variances are not assumed			1.343	27.691	.190	.328	.244	-.172	.828

t-value significant at $p < 0.05$

Table 5 indicates that there is no statistically significant difference between the academic performance of male and female PMTs in calculus after learning calculus using a remedial teaching approach, since the significance (2-tailed) value is 0.152, which is greater than the 0.05 alpha value. Furthermore, the results showed that the males (GPA = 3.15, SD = 0.871) performed better in calculus than the females (GPA = 2.83, SD = 0.990) conditions; t (90) = 1.445, p = 0.152. Nonetheless, there is a mean difference of 0.328 in favor of the male pre-service teachers at 90 degrees of freedom. This means that both groups gained from learning calculus using the remedial teaching approach, but the male students gained more than their female counterparts. An independent samples t-test was conducted to establish the significance of the difference between genders in calculus scores. The findings indicate that the male students understood the calculus concepts better than the female students. The

findings of this study established that there is no statistically significant gender difference between the performance of male and female PMTs in calculus after learning the subject using the remedial teaching approach. This implies that the remedial teaching approach has no significant effect on PMTs' performance in calculus.

The findings of this study are similar to those of Ganley (2018), who investigated gender differences in mathematics achievement. The study findings indicated no statistically significant gender difference in mathematics achievement in preschool and elementary schools. However, gender differences in mathematics performance start in males in high school and college. This is not surprising because the findings of this study support this. This could be because at the preschool and elementary school levels, girls are mostly at home and have more time for reading than boys. At the high school and college level, most students are in the boarding house, and most males have more time and concentration for reading than their female counterparts. At the high school and college levels, male students develop more interest in solving mathematics problems than female students. It makes sense to conclude that male PMTs perform better in calculus than their female counterparts.

8. Conclusions

Based on the findings of this study, the following conclusions were drawn based on the research objectives.

i. PMTs in colleges of education demonstrated an understanding of calculus concepts using the remedial teaching approach. This indicates that PMTs in colleges of education are capable of achieving high scores in calculus if they are given the necessary support, such as allocating more time for teaching and learning calculus.

ii. The analysis of objective two (2) using an independent samples t-test statistic showed that male PMTs performed better in calculus than their female counterparts. Additionally, the findings from the independent samples t-test of this study failed to reject the claim that **t**here is no statistically significant gender difference in calculus performance among PMTs in colleges of education in Ghana after learning the subject using a remedial teaching approach. Hence, remedial teaching can bridge the gender gap in the academic performance of PMTs in calculus at the college level.

9. Recommendations

Based on the findings of this study, the following recommendations were made for policymakers and for further research:

9.1 Recommendations for policymakers

i. Mathematics teachers should allocate more time for teaching and learning calculus to enable them to complete the calculus course outline and enhance the conceptual understanding of the subject.

ii. Mathematics teachers should provide equal opportunities to both males and females in the mathematics classroom.

9.2 Recommendations for further studies

Based on the study findings, the following suggestions were made:

i. Further study could be conducted on the academic achievement of basic PMTs in other strands of mathematics using a remedial teaching approach at the college level of education.

ii. Further research should be conducted to assess PMTs' perceptions concerning the teaching and learning of calculus using a remedial teaching approach.

10. Author bibiography

Dr. Zutaah Puotier, a Ghanaian mathematician, holds a Doctor of Philosophy in Mathematics Education from Kenyatta University. His research interests include technology integration, gender issues, STEM education, and inclusive education. He has published peer-reviewed research papers, textbooks, and has presented at conferences and seminars. He is a reviewer of Journals. Dr. Zutaah is a member of the Ife Summer Institute of Advance Studies and the Association of Mathematics Teacher Educators.

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Appendix A

PRESBYTERIAN COLLEGE OF EDUCATION

AKROPONG AKUAPEM
(FOUNDED 1948)

P. O. Box 27
Akropong-Akuapem
Ghana, West Africa

Email: info@pceakropong.edu.gh
Website: www.pceakropong.edu.gh
Tel: +233 (0)553970432(0)506851969
Bankers: GCB Bank, Akropong-Akuapem

Our Ref: PCE/AA/N.8/VOL.4
Your Ref:

January 14, 2022
Date:

MR. PUOTIER ZUTAAH
PRESBYTERIAN COLLEGE OF EDUCATION
P.O. BOX 27
AKROPONG-AKUAPEM

Dear Sir,

RE: PERMISSION TO COLLECT RESEARCH DATA IN PRESBYTERIAN COLLEGE OF EDUCATION, AKROPONG-AKUAPEM, GHANA

With reference to your letter dated 19th January, 2022, I write to inform you that you have been granted permission to conduct your research in the Presbyterian College of Education, Akropong.

We look forward to working with you for the growth and development of the College.

Thank you.

Yours faithfully,

Rev. Dr. Nicholas Apreh Siaw
Principal

Mother of our Schools

Research permit from Presbyterian College of Education, Akropong, Ghana

Appendix B

Grading system in Ghana's Colleges of Education

Grade	Range of the Scores (%)	Interpretation	Grade Point
A	80-100	Excellent	4.0
B+	75-79	Very Good	3.5
B	70–74	Good	3
C+	65–69	Credit	2.5
C	60–64	Credit	2
D+	55–59	Pass	1.5
D	50–54	Pass	1
E	Less 50	Fail	0
IC	Incomplete	Did not complete exams or assignments	0

Source: Assessment unit of the Presbyterian College of Education