

# Pre-service teachers' mathematics achievement, attitude, and anxiety: The moderative role of pre-service teachers' interest in the learning process

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## ABSTRACT

The aim of the study was meant to investigate the moderative role of pre-service teachers' interest on mathematics achievement, attitude and anxiety during teaching and learning process. The study was conducted at Akrokerrri College of Education Adansi, Ghana on pre-service teachers with a population of 300. A sample of 206 pre-service teachers were involved in the study. Questionnaires were designed with regards to the four main constructs identified in the study. The questionnaires were analyzed using the structural equation model. The findings revealed that pre-service mathematics teachers' attitude has a direct positive effect on pre-service teachers' mathematics achievement. Mathematics anxiety has a positive effect and is statistically insignificant on mathematics achievement. Finally, the moderating effect of mathematics interest on the relationship between mathematics attitude and mathematics achievement result was negative and it is statistically insignificant.

**Keywords:** pre-service teachers' interest, mathematics achievement, attitude and anxiety, teaching and learning process and moderating effect

## INTRODUCTION

Over the years there has been several classroom variables that are known to impact on the successful classroom mathematics achievement. The teaching and learning of mathematics are a process that involve students and teachers, this alone cannot be successful if we do not investigate certain variables that could possibly impact on teaching and learning of students' mathematics achievement. Notably among them are mathematics achievement, attitude, anxiety, and interest. This study was meant to investigate how pre-service teachers' interest in mathematics can influence achievement, attitude, and anxiety during classroom teaching and learning process and also to explore the inter relationship between these variables during classroom discourse.

Appiah et al. (2022) recommend that mathematics teachers should aid students' attitudes towards mathematics in order to accelerate mathematics performance (MP). This implies that students' attitudes can influence performance in mathematics, as attitudes was known to predict students' achievements in mathematics. However, the study of Papanastasiou (2002) on the effects of background and school factors on mathematics achievement noted that although previous studies are of the views that attitudes have direct effect on mathematics outcome, they were not statistically significant. The study of Papanastasiou (2002) implies that attitudes cannot be used to predict students' outcome in mathematics.

Anxiety of mathematics has to do with the fear associated with mathematics, this may result into like or dislike of the subject as a result influencing achievement. Meanwhile recent study shows that learners with high level of anxiety in mathematics turn to have no interest in mathematics and this in the long run impact negatively on achievement. According to Musa et al. (2017), learners with very high level of mathematical interest turn achieve higher in mathematics. However, this might not always be the case as other classroom variables can equally impact on students' mathematical achievement even though students might have high interest in mathematics (Hashim et al., 2021). In view of that, this study was meant to investigate how pre-service teachers' mathematical interest could impact or relates with other classroom variables such as mathematical achievement, attitudes and anxiety. Hence the study is meant to investigate the moderating role of pre-service mathematical interest on mathematics achievement, attitudes and anxiety during classroom discourse or learning process.

## Statement of the Problem

There are several variables that could impact either positively or negatively on Pre-service teachers' mathematics achievement during classroom discourse or learning process. Many studies concentrated much on just pre-service teachers' low performances during internal and external examination, without actually looking at other variables that could impact on pre-service teachers' mathematical achievement during classroom discourse. Other studies also concentrated much on teacher and student factors as well as learners' cognitive factors affecting mathematics achievement. Concentrating on pre-service teachers' cognitive factors alone as a predictive factor impacting on mathematics achievement might not be enough as other classroom variables might impact either positively or negatively on mathematics achievement.

Significant among these classroom factors are attitudes, anxiety and interest on mathematics achievement. Pre-service teachers' attitudes, anxiety and interest could have a direct impact on mathematics achievement, these variables are known to relate to mathematics teaching and learning. In view of the above this study was meant to investigate the interconnectedness of pre-service teachers' attitudes, anxiety and interest on mathematics achievement during classroom discourse. The study is to investigate the moderative role of pre-service teachers' mathematical interest on attitudes, anxiety and achievement. Even though there was some significant study on Pre-service mathematics teachers' attitudes, anxiety and interest and achievement. There has not been much work on how these variables could be moderated by a particular variable in a single study and that was the gap of this study. The gap in this study was how Pre-service mathematics teachers' interest in mathematics could moderate or impact on attitudes, anxiety and mathematics achievement in a single study.

## Research Objectives

1. To find out the impact of pre-service teachers' mathematics attitude on achievement.
2. To find out the impact of pre-service teachers' mathematics anxiety on achievement.
3. Determine the moderating effect of pre-service teachers' mathematics interest on the relationship between attitude and achievement.

## Research Questions

1. Does pre-service teachers' mathematics attitude impact on mathematics achievement?
2. Does pre-service teachers' mathematics anxiety impact on mathematics achievement?
3. What is the moderating effect of pre-service teachers' mathematics interest on the relationship between attitude and achievement?

## Significant of the Study

This study is worth doing and very important for mathematics education. In fact, mathematics education can never thrive well if we do not critically look at the teachers who are supposed to mentor, facilitate and teach our students. This is one of the main reasons why it is necessary to conduct a study on the Pre-service mathematics teachers who are supposed to be in charge of the teaching and learning of mathematics (mathematics education) after graduating from the colleges of education in Ghana.

Several studies over the years concentrated much on students' mathematics achievement, without being critical about the Pre-service teacher in college who is going through mentorship and training to become a qualified professional and fully prepared to teach in the Ghanaian schools. It is worth noting to actually find out some of the issues surrounding some of these pre-service teachers in order to make an informed decision in future. The findings of this study on pre-service teachers at Akrokerrri College of Education will not only help to improve classroom practices of these pre-service teachers but also will be available to those researchers in the area of mathematics education.

## Limitation of the Study

Cost and time of designing a questionnaire was a major challenge of the study. Some of the respondents were very reluctant with regards to responding to the questionnaire, this makes data collection very difficult. Also, there was a challenge with getting all pre-service teachers to administer the questionnaire at the same time, this was because pre-service teachers offer different programs and assembling all of them at once was a difficult task. I have to wait on different days to administer the questionnaire to pre-service teachers on the days they have lectures with regards to the programs they offer. This also means that the collection of the questionnaires (instrument) was a challenge as I could not collect all the questionnaires from the pre-service teachers at the same time because of these challenges, six pre-service teachers could not return their questionnaires (instruments).

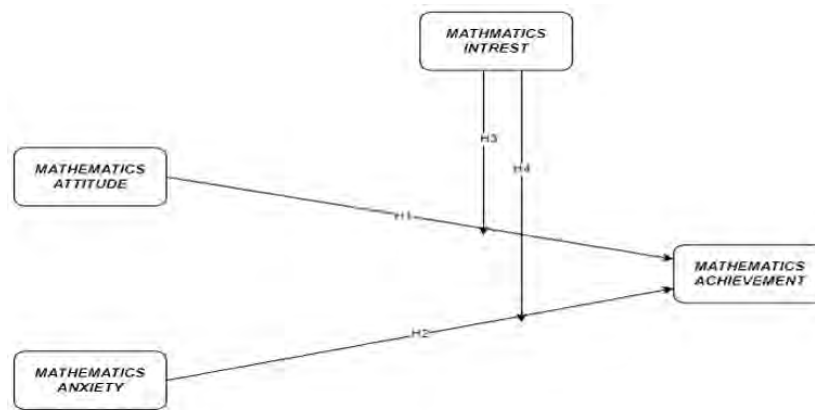
## Delimitation of the Study

Studies revealed that there were other factors that could impact on students' mathematics achievement, however, due to the nature of this study, all variables cannot be investigated in a single study. The study will only be restricted to the variables as mentioned in the study.

## LITERATURE REVIEW

### Conceptual Framework

**Figure 1** shows the conceptual framework.



**Figure 1.** Conceptual framework on moderative role of mathematics interest on achievement, attitude, & anxiety (Source: Field Survey, 2023)

### Effect of Mathematics Attitude on Achievement

The study of Andima (2001) reveals that students' attitudes can be positive or negative, both can impact on learners' mathematics achievement. In other words positive attitudes produce positive reinforcement that can predict learners' mathematics achievement, whereas negative attitudes also produce negative reinforcement that also predict learners' mathematics achievement. Finally, the study of Andima (2001) implies that students' attitudes towards mathematics is a panacea to greater achievement in mathematics. In view of this, teachers must consider the attitudes of their learners during teaching and learning, they should reshape the negative attitudes of learners to enhance classroom mathematics delivery that can foster mathematics achievement. Similarly, the works of Ajiuksmo and Saputri (2017) share a similar view that students' attitudes towards mathematics, the knowledge of students' attitudes toward mathematics is very necessary as this helps teachers in the classroom delivery. Students' attitude toward mathematics differs, this implies that students have different attitudes towards mathematics therefore, teachers must demonstrate a high level of professionalism during classroom discourse. Each student needs a different kind of support and mathematics teachers must be able to support each individual student. This will not only enhance classroom discourse between students and teachers but also stimulate the development of a positive attitude toward mathematics (Hwang & Son, 2021).

However, the study of Kasimu and Imoro (2017) disagrees with earlier studies that students' attitudes predict mathematics achievement, they are of the view that students' attitudes have nothing to do with mathematics achievement. The study implies that students' attitudes do not predict mathematics achievement. Meanwhile, they emphasized that even though students' attitudes do not influence or predict mathematics achievement, it must be given the necessary attention as it can affect other variables in relation to mathematics achievement. Similarly, Libradilla et al. (2023) also support the works of earlier studies that there is no significant relationship between student attitude towards mathematics and achievement.

### Effect of Mathematics Anxiety on Achievement

Mathematics anxiety is defined as the fear learners are confronted with when they are to engage in a mathematical task. This anxiety as related to mathematics is negatively correlated with mathematics achievement (Demedts et al., 2022). Recent study on mathematics anxiety shows that mathematics-related anxiety must be given the needed attention as this has a devastating consequence on performance/achievement. Different forms of math anxiety were identified to impact on mathematics achievement (Caviola et al., 2022), in that regard the study of Putawain and Wood (2022) attests to the fact that higher mathematical anxiety impacts negatively on mathematics achievement. Hence there is a need to reduce the different forms of mathematics anxiety, this will help to improve the performance of learners in mathematics. Similar study by Luu-Thi et al. (2021), on mathematics anxiety confirms that the number of mathematical anxieties among students has risen. The findings revealed that mathematics anxiety has a significant influence on grade, academic achievement and career choices and learners' ability to cope. Also, the study of Zhang et al. (2019) supports the assertion that mathematics anxiety negatively influences the performance of students. Mathematics anxiety has the potential of decreasing the MP of students. The study suggested that students should be given a strong foundation in mathematical knowledge, this will be beneficial for overcoming mathematics anxiety. Also, the use of multiple interventions targeting primary school-aged children, since anxiety begins in early childhood was suggested (Sheffield & Hunt, 2007). However, the study of Salinas et al. (2019) contradicts the earlier studies on mathematics anxiety, that mathematics anxiety significantly impacts on performance. The findings revealed that students' level of mathematics anxiety does not determine students' performance in mathematics. The implication of the study was that no matter how high or low, the level of mathematics anxiety, students' performance will still be low, high, average or remain the same.

### Mathematics Interest on Attitude and Achievement

According to Hashim et al. (2021), students' interest in mathematics is a strong predictor to attitudes and performance in mathematics. They further stressed that all variables mentioned, that is interest, attitude, learning habit and mathematics achievement were all necessary towards the enhancement of good MP. The implication of the study was that, during teaching and

**Table 1.** Reliability analysis

Variables	Number of item(s)	Cronbach's alpha
SMA	3	.946
MA	3	.913
MATT	5	.941
SIM	7	.927

learning process all the variables are equally and must be fostered by teachers to achieve higher level students' mathematics achievement. This was one main reason why the teacher must try to do everything possible to arouse the interest of their learners. As the study of Kalpana and Malathi (2019) revealed that students' interest in mathematics directly impact on achievement of higher secondary students. This implies that, students' mathematical interest greatly impacts on the two variables that is attitude and achievement. In view of this it is very necessary to consider students interest in mathematics as it can affect other variables with regards to mathematics learning. Hence learners with higher interest in mathematics can enhance positive attitudes in mathematics learning and this can finally impact on achievement. Similarly, the study of Musa et al. (2017) confirms that students' interest in learning mathematics through the model of experiential learning increased and this had impacted positively on students' mathematics achievement. In line with the above the study of Kihwele and Mkomwa (2023) that students' interest in learning mathematics significantly improved and this has positively affected their performance. The study emphasized that there was an active participation of learners and attitudinal change in behavior towards mathematics as learners develop interest in mathematics.

However, the study of Wong and Wong (2019) on the relationship between interest and MP emphasized that even though students were relatively interested in studying mathematics, the result was not statistically significant. This implies that students' interest in mathematics does not have any direct impact on performance. The findings of the study pointed to the fact that students with low performance in mathematics should be encouraged to have interest in the subject in order to improve performance. Similarly, Ryan et al. (2022) also attest to the fact that there was a high level of student interest and engagement in mathematics after first year of secondary education, despite recording a decline in performance in mathematics. Furthermore, the work of Asmira et al. (2021) also support a decrease in performance though there was an increase in students' interest overtime.

## METHODOLOGY

The study was conducted at the Akrokerri College of Education Adansi, Ghana on preservice teachers with a population of three hundred. A sample of 200 pre-service teachers were involved in the study. Questionnaires were designed with regards to the constructs identified in the study, four main constructs were identified in the study, these are students' anxiety on mathematics achievement, students' interest on mathematics achievement, students' attitude on mathematics achievement and students' mathematics achievement. The questionnaires were administered to the pre-service teachers and was analyzed using the structural equation model (SEM). The sample selection was done appropriately in accordance with Gill et al. (2010) sample selection tables, that a population size of three hundred (300) a sample of two hundred and six (206) should be selected for the study. After the sample selection was done based on Gill et al. (2010), simple random sampling techniques was used appropriately to select the sample of 206 for the study. **Table A1** in **Appendix A** show students' anxiety, interest, and attitude on mathematics achievement, and students' mathematics achievement.

### Non-Response

Questionnaire was administered to 206 pre-service teachers of Akrokerri College of Education. Out of this pre-service teachers, six of them could not return the questionnaires that was administered to them after two days, this was treated as non- response. Finally, 200 pre-service teachers return the questionnaires that was administered to them.

## RESULTS

### Reliability Analysis

Internal consistency of the measurement items was assessed using Cronbach's alpha (CA) analysis in SPSS (v.23) software. Internal reliability or consistency is said to be achieved when the alpha score is at least 0.7 (Pomegbe et al., 2020). As demonstrated in **Table 1**, peer tutoring (PT) had a CA of 0.893, MP had a CA of 0.886, mathematics anxiety (MA) had a CA of 0.879 while student interest (SI) had a CA of 0.885.

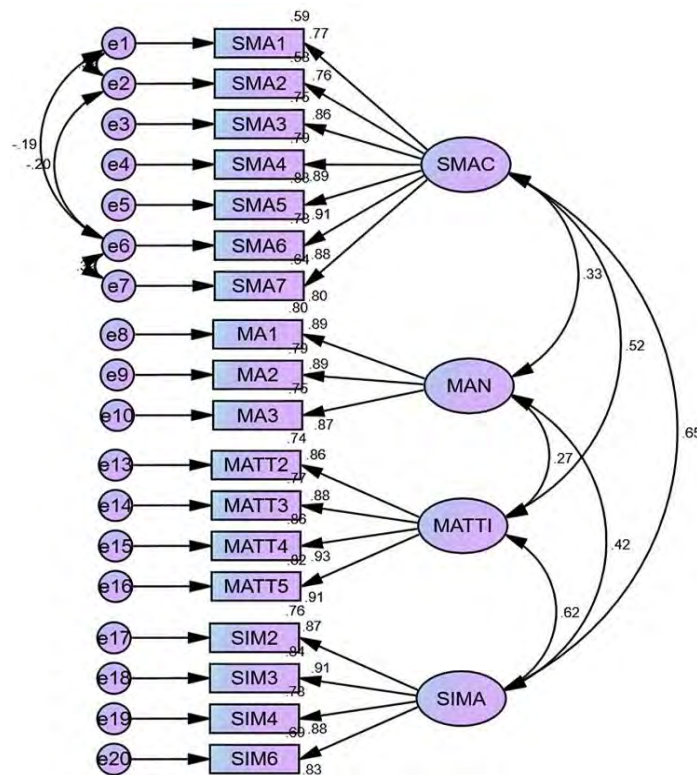
### Confirmatory Factor Analysis

With the aid of IBM SPSS Amos (v.23) software, a confirmatory factor analysis was conducted with the principal component estimate to test the measurement model. The measurement model was conducted, and all the produced fit indices were found within their required threshold values, as follows: CMIN/df being 1.725 ( $\leq 3.000$ ), TLI=0.967; CFI=0.973; RMSEA=0.060; RMR=0.048; P-close=0.105. The model, therefore, has a good fit with observed data. **Table 2** and **Figure 2** are a summary of the measurement model fit indices.

**Table 2.** Confirmatory factor analysis

Variable	Standard loadings
SMA: CA=.946; CR=.944; & AVE=.707	
SMA1	.770
SMA2	.760
SMA3	.864
SMA4	.889
SMA5	.911
SMA6	.881
SMA7	.800
MA: CA=.913; CR=.914; & AVE=.779	
MA1	.892
MA2	.888
MA3	.867
MATT: CA=.941; CR=.941; & AVE=.798	
MATT2	.859
MATT3	.880
MATT4	.927
MATT5	.906
SIM: CA=.927; CR=.929; & AVE=.767	
SIM2	.873
SIM3	.914
SIM4	.884
SIM6	.829

Note. Model fit indices: CMIN=215.653; df=125; CMIN/df=1.725; TLI=.967; CFI=.973; RMR=.048; RMSEA=.060; & P-close=.105

**Figure 2.** Summary of measurement model fit indices (Source: Field Survey, 2023)

### Discriminant Validity

For the discriminant validity, the squares of AVE values for each construct are compared with the individual inter-construct correlations, as presented in **Table 3** (Fornell & Larcker, 1981). It emerged that all the squared AVE values were greater than each of the inter-construct correlations.

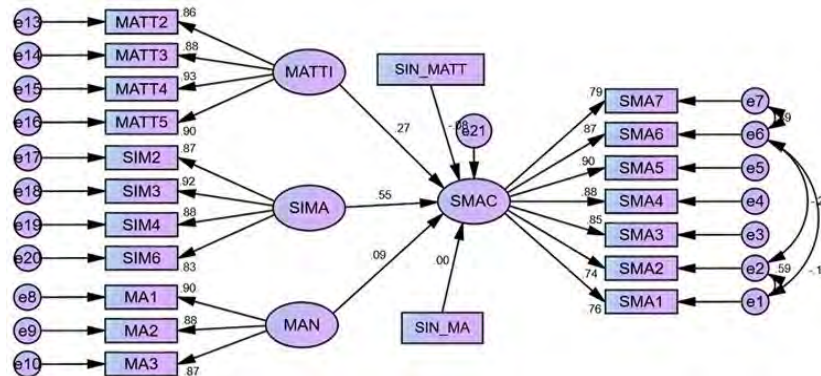
### Structural Model

Following the evaluation of the measurement model's fit, the data underwent additional analysis by looking at the presumed relationship between the endogenous and exogenous variables of the study's framework. To test the direct relationships, this was done by estimating various structural models in IBM SPSS Amos 23. The estimates for the test of direct relationships are shown visually in **Figure 3** and **Table 4**, respectively.

**Table 3.** Discriminant validity

Variables	SMA	MA	MATT	SIM
SMA	<b>.841</b>			
MA	.328***	<b>.883</b>		
MATT	.516***	.268***	<b>.894</b>	
SIM	.645***	.419***	.619***	<b>.876</b>

Note. \* $p < 0.0500$ ; \*\* $p < 0.01000$ ; & \*\*\* $p > 0.0001$

**Figure 3.** Estimates for test of direct relationships (Source: Field Survey, 2023)**Table 4.** Path analysis

Path	Standard estimate	Standard error	CR	p-value
MATTI→SMAC	0.237	0.056	4.199	0.000
MAN→SMAC	0.064	0.045	1.433	0.152
SIMA→SMAC	0.479	0.063	7.582	0.000
SIM_MA→SMAC	0.000	0.007	-0.005	0.996
SIM_MATT→SMAC	-0.010	0.008	-1.278	0.201

#### **Does pre-service teachers' mathematics attitude impact on achievement?**

From **Table 4**, mathematics attitude positively impacted on the mathematics achievement of students with a p-value less than 0.01 ( $\gamma = 0.237$ ,  $CR = 4.199$ ). The results show that there is a 23.7% positive effect of students' mathematics attitude on achievement in mathematics. In view of the above findings reflect the study of Andima (2001), that students' attitudes can be positive or negative, both can impact on learners' mathematics achievement. In order words positive attitudes produce positive reinforcement that can predict learners' mathematics achievement, whereas negative attitudes also produce negative reinforcement that also predict learners' mathematics achievement. The study was consistent with Andima (2001).

#### **Does pre-service teachers' mathematics anxiety impact on achievement?**

Mathematics anxiety has a positive effect and is statistically insignificant on mathematics achievement ( $\gamma = 0.064$ ,  $CR = 1.433$ ). This means that mathematics achievement was 6.0% predicted by their mathematics anxiety.

#### **What is the moderating effect of pre-service teachers' mathematics interest on the relationship between attitude and achievement?**

The moderating effect of mathematics interest on the relationship between mathematics attitude and mathematics achievement resulted is negative and it is statistically insignificant ( $\gamma = -0.010$ ;  $CR = -1.278$ ).

## **DISCUSSION**

### **Discussion of Research Objective 1**

Research objection 1 is to find out impact of pre-service teachers' mathematics attitude on achievement. Research objective one was meant to determine the effect of pre-service teachers' mathematics attitude on achievement. The result of the study, as shown in **Table 4**, indicated that pre-service teachers' mathematics attitude impacted positively on achievement with a p-value less than 0.01 ( $\gamma = 0.237$ ,  $CR = 4.199$ ). This finding was in line with the work of Andima (2001) that attitudes can be positive or negative, both can impact on mathematics achievement. In order words positive attitudes produce positive reinforcement that can predict learners' mathematics achievement, whereas negative attitudes also produce negative reinforcement that also predict learners' mathematics achievement. The study was consistent with Andima (2001) that mathematics attitude impact positively on mathematics achievement. Similarly, work of Ajisuksmo and Saputri (2017) shares a similar view that students' attitudes towards mathematics were significantly correlated to achievement in mathematics. There is a significant role of students' attitudes towards mathematics, knowledge of students' attitudes toward mathematics is very necessary as this help teachers in classroom delivery.



However, the study of Kasimu and Imoro (2017) disagree with earlier studies that students' attitudes as a predictor of mathematics achievement, they are of the view that, students' attitudes have nothing to do with mathematics achievement. Similarly, Libradilla et al. (2023) also support the works of earlier studies that, there is no significant relationship between student attitude towards mathematics and achievement. The implication from literature with regards to the result of this study means the students (pre-service teachers) positive attitude towards mathematics predict mathematics achievement. This means pre-service teachers attitude impact positively on mathematics achievement, should be made known to pre-service teacher through the lecturers in the colleges of education regarding the effect of pre-service teachers' attitude on mathematics achievement and how it can impact on future classroom mathematics delivery process.

### Discussion of Research Objective 2

Research objection 2 is to find out the impact of pre-service teachers' mathematics anxiety on achievement. Mathematics anxiety has a positive effect and is statistically insignificant on mathematics achievement ( $\gamma=0.064$ ,  $CR=1.433$ ). This contradicts the study of Luu-Thi et al. (2021), on mathematics anxiety, that mathematical anxiety among students has risen and it has a significant impact on achievement. In that regard the study of Putawain and Wood (2022) attests to the fact that higher mathematical anxiety impact negatively on mathematics achievement. Hence there is the need to reduce the different forms of mathematics anxiety, this will help to improve performance of learners in mathematics. However, the study of Salinaset al. (2019) contradicts the assertion that mathematics anxiety significantly impacts on performance. Their findings revealed that student's level of mathematics anxiety does not determine students' performance in mathematics.

The results of pre-service teachers' anxiety on mathematics achievement were positive, however it was statistically insignificant. The implication was that though pre-service teachers' in Akrokerrri College of Education mathematics anxiety was positive the value was so small that it could not impact on their mathematics achievement or performance. It also implies that pre-service mathematics teachers' mathematics anxiety though was positive, mathematics achievement still remains the same (ie it has no impact on achievement). This was in line with the study of Salinas et al. (2019) that contradicts the earlier studies on mathematics anxiety, that mathematics anxiety significantly impacts on performance. The findings revealed that student's level of mathematics anxiety does not determine students' performance in mathematics. The implication of the study was that no matter how high or low, the level of mathematics anxiety, students' performance will still be low, high, average or remain the same. Finally, the study of Zhang et al. (2019) contradict the findings of pre-service teachers' mathematics anxiety at Akrokerrri College of Education on mathematics achievement, that mathematics anxiety negatively influence the performance of students. Mathematics anxiety has the potential of decreasing MP of students. Pre-service teachers' mathematics anxiety at Akrokerrri College of Education was positive, statistically insignificant and has no impact on pre-service teachers' mathematics achievement. However, since pre-service teachers' mathematics anxiety was a positive, study suggest that pre-service teachers should be given a strong foundation in mathematical knowledge, this will be beneficial for overcoming mathematics anxiety. This finding implies that pre-service teacher's mathematical anxiety was statistically insignificant and does not impact on mathematics achievement. However, this does not mean that pre-service teacher's mathematical anxiety must not be taken seriously. This findings on mathematics anxiety with regards to pre-service teachers must be given the necessary attention as it can affect other variables in relation to mathematics achievement.

### Discussion of Research Objective 3

Research objection 3 is to determine the moderating effect of pre-service mathematics interest on the relationship between attitude and achievement. The moderating effect of mathematics interest on the relationship between mathematics attitude and mathematics achievement result was negative and it is statistically insignificant ( $\gamma=-0.010$ ;  $CR=-1.278$ ). This finding was in alignment with study of Wong and Wong (2019) on the relationship between interest and MP emphasized that even though students were relatively interested in studying mathematics, the result was not statistically significant. This implies that pre-service teachers' interest in mathematics does not have any direct impact on attitude and achievement. Th findings of the study pointed to the fact that pre-service teachers with low performance in mathematics should be encouraged to have interest in the subject in order to improve performance. However, the results of the study contradict the work of Hashim et al. (2021) confirmed that, students' interest in mathematics is a strong predictor to attitudes and performance in mathematics. Also, the study of Kalpana and Malathi (2019) revealed that students' interest in mathematics directly impact on attitude and achievement of higher secondary students though the study of this study revealed a negative relationship and statistically insignificant. Finally, Kihwele and Mkomwa (2023) that students' interest in learning mathematics significantly improved and this has positively affected their performance. The study emphasized that there was an active participation of learners and attitudinal change in behavior towards mathematics as learners develop interest in mathematics. This implies that work of Kihwele and Mkomwa (2023) contradicts our results. Their findings attest to the fact that there was a strong relationship between attitude and mathematics achievement as students develop much interest in learning mathematics. This means students' interest in mathematics shows a positive relationship on attitude and performance (achievement) and it was statistically significant, but result of study on pre-service teachers' mathematical interest, attitude, and achievement shows a negative relationship and it was statistically insignificant.

## CONCLUSIONS

The focus of the study was meant to investigate the moderative role of pre-service teachers' interest on mathematics achievement, attitude and anxiety during teaching and learning process. Questionnaires were administered to pre-service teachers on interest, mathematics achievement, attitude and anxiety.

SEM was used to analyze the data and the results show that pre-service teachers' mathematics attitude impacted positively on achievement. Pre-service teachers' Mathematics anxiety has a positive effect and is statistically insignificant on mathematics achievement. Finally, the moderating effect of pre-service teachers' mathematics interest on the relationship between attitude and achievement show a negative result and it is statistically insignificant.

### Recommendations

Based on the findings of this study, the following recommendations were made: Students attitude and anxiety are a key indicator to mathematics achievement, as it is a predictor to pre-service teachers mathematics achievement (performance). Mathematics lectures in the colleges of education in Ghana should be mindful on how to help colleges of education students to overcome negative mathematics attitude and anxiety known to impact negatively on mathematics achievement. This will not only reinforce confidence and enhance performance at the college level but also pre-service teachers not to transcend these negative attitude and mathematics anxiety to the learners they are supposed to teach in future.

### Suggestions for Future Studies

The study was conducted on pre-service teachers at Akrokerri College of Education, Adansi in the Ashanti Region of Ghana. This means the findings of this study could not be a true representation or reflection of the sample size regarding the whole region of Ashanti. Therefore, it could be necessary to conduct a similar study regarding all the colleges of education in the Ashanti Region of Ghana with an increased sample size.

Also, a replica of this study could be conducted at the various schools in the Ashanti Region of Ghana, this will help the Ghana Education Service to know some of the challenges of their teachers in relation to mathematics education.

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**Ethical statement:** The authors stated that the study was approved by the Mathematics Education Research Ethics Committee of Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) on 20 February 2023 (Approval code: ACT 1026). Written informed consent was obtained from Heads of the Departments and lecturers, as well as from the students.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

## REFERENCES

- Ajisuksmo, C. R. P., & Saputri, G. R. (2017). The influence of attitudes towards mathematics, and metacognitive awareness on mathematics achievements. *Creative Education, 8*(3), 486-497.
- Andima, P. (2001). *A study of attitudes towards mathematics among learners in grade 10 in Namibia* [Master's degree, Oklahoma State University].
- Appiah, J. B., Korkor, S., Arthur, Y. D., & Obeng, B. A. (2022). Mathematics achievement in high schools, the role of the teacher-student relationship, students' self-efficacy, and students' perception of mathematics. *International Electronic Journal of Mathematics Education, 17*(3), em0688. <https://doi.org/10.29333/iejme/12056>
- Asmira, A., Rusli, & Sabri. (2021). Improving students' interest and achievement in mathematical learning through problem-based learning model. In *Proceedings of the International Conference on Educational Studies in Mathematics* (pp. 303-307). Atlantis Press.
- Caviola, S., Toffalini, E., Giofre, D., Ruiz, J. M., Szucs, D., & Mammarella, I. C. (2022). Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychological Review, 34*, 363-399. <https://doi.org/10.1007/s10648-021-09618-5>
- Demedts, F., Reynvoet, B., Sasanguie, D., & Depaepe, F. (2022). Unraveling the role of math anxiety in students' math performance. *Frontiers in Psychology, 1*.
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39. <https://doi.org/10.2307/3151312>
- Gill, J., Johnson, P., & Clark, M. (2010). *Research methods for manager*, SAGE Publications.
- Hashim, S., Masek, A., Mohd Mahthir, B. N. S., Rashid, A. H. A., & Nincarean, D. (2021). Association of interest, attitude and learning habit in mathematics learning towards enhancing students' achievement. *Indonesian Journal of Science and Technology, 6*(1), 113-122.
- Hwang, S., & Son, T. (2021). Students' attitude toward mathematics and its relationship with mathematics achievement. *Journal of Education and e-Learning Research, 8*(3), 272-280.
- Kalpna, S., & Malathi, V. A. (2019). A study on interest in mathematics interest and its relation to academic achievement in mathematics among higher secondary students. *International Journal of Trend in Scientific Research and Development, 3*(4), 1246-1254.
- Kasimu, O., & Imoro, M. (2017). Students' attitudes towards mathematics: The case of private and public junior high schools in the East Mamprusi District, Ghana. *Journal of Research & Method in Education, 7*(5), 38-43.



- Kihwele, J. E., & Mkomwa, J. (2023). Promoting students' interest and achievement in mathematics through "King and Queen of mathematics" initiative. *Journal of Research in Innovative Teaching and Learning*, 16(1), 115-133.
- Libradilla, A. A., Morales, D. R. B., Piamonte-Bacatan, R. J., & Misoles, P. A. (2023). Examining the association between attitude towards mathematics and student achievement. *International Journal of Research Publication and Reviews*, 4(7), 1040-1046.
- Luu-Thi, H.-T., Ngo-Thi, T.-T., Nguyen-Thi, M.-T., Thao-Ly, T., Nguyen-Duong, B.-T., & Tran-Chi, V.-L. (2021). An investigation of mathematics anxiety and academic coping strategies among high school students in Vietnam: A cross-sectional study. *Frontiers in Education*, 6. <https://doi.org/10.3389/feduc.2021.742130>
- Musa, H., Amaluddin, & Kasrah. (2017). Increasing interest in mathematical learning through model application *experiential learning*. In *Proceedings of the University of Muhammadiyah Malang's 1<sup>st</sup> International Conference of Mathematics Education* (pp. 21-23). Atlantic Press.
- Papanastasiou, C. (2002). Effects of background and school factors on the mathematics achievement. *Educational Research and Evaluation*, 8(1), 55-70.
- Pomegbe, W. W. K., Li, W., Dogbe, C. S. K., & Otoo, C. O. A. (2020). Enhancing the innovation performance of small and Medium-sized enterprises through network embeddedness. *Journal of Competitiveness*, 12(3), 156-171. <https://doi.org/10.7441/joc.2020.03.09>
- Putawain, D. W., & Wood, P. (2023). Anxiety in the mathematics classroom: Reciprocal relations with control and value, and relations with subsequent achievement. *ZDM-Mathematics Education*, 55, 285-298. <https://doi.10.1007/s11858-022-01390-2>
- Ryan, V., Fitzmaurice, O., & O' Donoghue, J. (2022). Student interest and engagement in mathematics after the first year of secondary education. *European Journal of Science and Mathematics Education*, 10(4), 436-454. <https://doi.org/10.30935/scimath/12180>
- Salinas, K. J. H., Tolibao, J. R., & Moneva, J. C. (2019). Student's anxiety in mathematics. *International Journal of Novel Research in Education and Learning*, 6(1), 46-55.
- Sheffield, D., & Hunt, T. E. (2007). How does anxiety influence maths performance and what can we do about it? *MSOR Connections*, 6(4), 19-23.
- Wong, S. L., & Wong, S. L. (2019). Relationship between interest and mathematics performance in a technology-enhanced learning context in Malaysia. *Research and Practice in Technology Enhanced Learning*, 14, 21.
- Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology*, 10, 1613. <https://doi.org/10.3389/fpsyg.2019.01613>

## APPENDIX A

**Table A1.** Students' anxiety, interest, & attitude on mathematics achievement & students' mathematics achievement

Variable	1	2	3	4	5
<b>Anxiety</b>					
1. Working with math makes me nervous.					
2. I get a sinking feeling when I think of learning math.					
3. Learning math is frustrating.					
4. I feel insecure about asking math questions in class.					
5. I get nervous when math teacher is in class.					
6. I have usually been at ease during mathematics test.					
7. I have usually been at ease in mathematics courses.					
8. Mathematics makes me feel uncomfortable and nervous.					
9. I get a sinking feeling when I think of trying hard mathematics problems.					
10. My mind goes blank, and I am unable to think clearly when working mathematics.					
11. Mathematics test would scare me.					
12. Mathematics makes me feel uneasy and confused.					
13. Mathematics makes me feel uncomfortable, restless, irritable, and impatient.					
<b>Interest</b>					
1. I like to answer questions in mathematics class.					
2. I like mathematics.					
3. I am interested in mathematics.					
4. Knowing a lot about mathematics is helpful.					
5. I spend many hours working on mathematics.					
6. I work more mathematics problems than I love to.					
7. I am excited when a new mathematics topic is announced.					
8. I want to learn more about mathematics.					
9. I study mathematics because it is a compulsory subject for advancement into another field.					
10. I give up easily on mathematics.					
11. I would rather be working on something else besides mathematics.					
12. I spend as little time as possible working mathematics.					
13. I am bored when working on mathematics.					
14. I am not eager to participate in discussions that involve mathematics.					
15. I do not like working on the homework given by my mathematics teacher.					
<b>Attitude</b>					
1. Mathematics is a useful subject.					
2. I use little mathematics outside school.					
3. Most mathematics has practical uses on the job.					
4. Most people do not use mathematics in their job					
5. I would like to work at a job that lets me use mathematics.					
6. Mathematics is not needed in everyday life.					
7. Mathematics is useful in solving everyday problems.					
8. A knowledge of mathematics is not necessary in most occupations					
9. I can get along well in everyday life without mathematics.					
10. Mathematics is more difficult for me than it is for most other learners.					
11. No matter how hard I try; I cannot understand mathematics.					
12. I cannot understand why some learners think mathematics is fun.					
13. I can get good grades in mathematics.					
14. Males are better in mathematics than females.					
15. Mathematics is good for creative people.					
16. I get good grades in mathematics.					
17. My parent (s) want me to learn more mathematics.					
<b>Mathematics achievement</b>					
1. I am more enthusiastic about mathematics than any other subject.					
2. I get good marks in mathematics.					
3. Mathematics help me to understand other subjects.					
4. Mathematics is an easy subject to pass.					
5. I feel happy when answering mathematics questions.					
6. My present knowledge in mathematics is high.					
7. I usually do well in mathematics.					
8. I do score high marks in mathematics.					
9. My performance in mathematics progress steadily.					
10. I struggle to obtain an average mark in mathematics.					
11. I mostly score very low marks in mathematics.					
12. My performance in mathematics does not increase steadily.					