

Prior mathematics achievement and mathematics self-efficacy as indicators for success in pre-service teachers' achievement in geometry and trigonometry

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Abstract: This study is a quantitative research and used a correlational research design to investigate the relationship between pre-service teachers' prior mathematics achievement (PA) at the senior high school and mathematics self-efficacy (MSEF) on learning and achievement in geometry and trigonometry in colleges of education. A sample of 449 pre-service teachers (264 males and 185 females) randomly selected from the population was used for the study. A closed-ended questionnaire was adapted and used as the main instrument to collect data. The result revealed a strong positive relationship between PA ($r = 0.543$), MSEf ($r = 0.542$), and geometry and trigonometry score. The study then concludes that the factors (PA, MSEf) have a positive relationship with geometry and trigonometry achievement. The study recommended that colleges of education should place much emphasis on pre-service teachers' entry grade in mathematics when considering the requirement for admission.

Keywords: Mathematics education, mathematics self-efficacy, geometry, trigonometry, pre-service teacher

Prestasi matematika awal dan efikasi diri matematika sebagai indikator keberhasilan prestasi guru prajabatan bidang geometri dan trigonometri

Abstrak: Penelitian ini merupakan penelitian kuantitatif dan menggunakan desain penelitian korelasional untuk mengetahui hubungan antara prestasi belajar matematika sebelumnya (PA) guru prajabatan di SMA dengan efikasi diri matematika (MSEF) terhadap pembelajaran dan prestasi belajar geometri dan trigonometri di sekolah tinggi pendidikan. Sampel dari 449 guru pra-jabatan (264 laki-laki dan 185 perempuan) yang dipilih secara acak dari populasi digunakan untuk penelitian ini. Kuesioner tertutup diadaptasi dan digunakan sebagai instrumen utama untuk mengumpulkan data. Hasilnya menunjukkan hubungan positif yang kuat antara PA ($r = 0.543$), SEf ($r = 0.542$), dan skor geometri dan trigonometri. Penelitian kemudian menyimpulkan bahwa faktor-faktor (PA, MSEf) memiliki hubungan positif dengan pencapaian geometri dan trigonometri. Studi ini merekomendasikan bahwa sekolah tinggi pendidikan harus lebih menekankan pada nilai masuk guru prajabatan dalam matematika ketika mempertimbangkan persyaratan untuk masuk.

Kata Kunci: Pendidikan matematika, efikasi diri matematika, geometri, trigonometri, guru prajabatan

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INTRODUCTION

Mathematics forms an integral part of our everyday life and it pervades the world around us. The social, economic, everyday life, scientific and technological development of nations depends mainly on Mathematics (Meremikwu & Erukoha, 2011; Pangadongan et al., 2022). Mathematics is regarded as the foundation of scientific and technical knowledge, which is essential for the socioeconomic growth of a country (Enu et al., 2015). Boinde (2009) described mathematics as the mother of all subjects since it is a course that the learner takes from kindergarten to university. The ability of a nation to contest effectively in the worldwide market today to a larger extent, depends on the mathematical literacy of its citizens (Sofowora, 2014). The universe cannot be read until we become conversant with the characters in which it is written and certainly it is written in a mathematical language (Ali & Jameel, 2016). Theories acquired in mathematics is applied in almost every field of work. Therefore, it is significant that a lot of emphases should be laid on the teaching and learning of mathematics from the basic school level through to the tertiary educational level. This is where students' prior knowledge in mathematics and their desire to obtain greater height is key.

Obielodan et al. (2021), Shulman (1986), and Vargas-Hernández and Vargas-González (2022) call for teaching to factor students' experiences and background information into instructional activities. This include prior mathematics achievement and mathematics self-efficacy. The self-efficacy of college students in mathematics seems to be influenced by the support they get from classmates, tutors, and parents. It has been discovered that tutoring had a large, favorable, and direct influence on academic self-efficacy and positive academic feelings in college-aged learners (Liu et al., 2018). As students enter higher education and enroll in increasingly difficult mathematics courses, they perceive a drop in tutor assistance and an increase in peer competitiveness, which may lead to a fall in their mathematical self-efficacy (Rice et al., 2013). Skaalvik et al. (2015) argued about the importance of mathematics self-efficacy in students' academic achievement. We agreed and contends that increasing self-efficacy in pre-service teachers' would translates into better performance in Geometry and Trigonometry course.

According to Nabie et al. (2018), trigonometry is a discipline of physical mathematics that deals with the conceptualization and application of ideas. The topic areas of trigonometry, according to Tuna (2013), include angles, the measurement of angles, triangles, and their connections. Tuna (2013) emphasized further that trigonometry combines geometric, pictorial, and algebraic thinking to give a place for making sense when addressing triangle, trigonometric expression, and graph-based issues. Trigonometry has applications in the sciences of Geography and Astronomy, as well as in Electricity, Cartography, Geometry, and Physics. Geometry and Trigonometry are taught at Ghana's colleges of education as content and pedagogical knowledge.

The content of Geometry and Trigonometry is taught in the second semester of the first year under the course title Geometry and Trigonometry. It is required that all students pursuing Degree in Primary Education take EBS 143. This course was previously taken by Diploma students with course code FDC 122. The course build directly on students' knowledge from high school. Students' prior experience and knowledge are important point of references for lesson planning and enactment. Therefore, the study assumed that having knowledge on pre-service teachers' prior mathematics achievement and self-confidence in

their ability to perform in geometry and trigonometry course is key to quality teacher instructions and preparations. Some research has been conducted to determine the association between pre-service teachers' academic success and academic environments. Some of the factors identified to have relationship are prior mathematics achievement at Senior High School and mathematics self-efficacy.

Problems related to learning Geometry and Trigonometry are common phenomena among students around the world (Mohd Rameli et al., 2014). This holds in the Ghanaian context too; some factors do relate pre-service teacher's Geometry and Trigonometry achievement positively or negatively (Anamuah-Mensah et al., 2004; Chief Examiner Report 2006). Among these influences include the prior mathematical ability of pre-service instructors, academic resources, the learning style of students, and Mathematics Self-Efficacy (Murray, 2013). Geometry and Trigonometry is a required subject for all pre-service teachers seeking a degree in Primary Education at the College of Education during the second semester of their first year. Over the academic years, pre-service teachers' achievement in the course has been poor. In 2007/2008 academic year, out of 9,168 candidates who registered for the (Geometry and Trigonometry) course in the Colleges of Education, only 3,961 representing 43.2% passed the end of semester examination and 5,207 representing 56.8% failed. Also, in 2017/2018 academic year, out of 12,322 candidates who registered for EBS 143 (Geometry and Trigonometry) course, only 7,541 representing approximately 61.2% of the candidates passed and as high as 4,781 representing approximately 38.8% failed the course (UCC summary of the result: July/August, 2007 and 2018).

Due to the foundational nature of EBS 143 (Geometry and Trigonometry), poor student accomplishment in Geometry and Trigonometry may hinder the performance of many second-year pre-service teachers in subsequent Mathematics courses. In addition, if a student fails to get a grade of at least 50% in this course, he or she will be required to retake the exam while studying the subsequent mathematical courses in the second year. Inadequate performance in this course affects students' grade point averages as well (GPA), which suggests that pre-service teachers do not graduate with adequate material and pedagogical expertise to instruct (Murray, 2013). This suggests that academics should investigate whether performance in Geometry and Trigonometry is correlated to past mathematics performance at the Senior High School level or to other variables. According to Zuya et al. (2016), the mathematics self-efficacy of teachers correlates significantly with their mathematics teaching self-efficacy. Therefore, pre-service teachers' self-efficacy knowledge is a significant predictor of their mathematics teaching skill. Investigations of Mathematics self-efficacy and learning during teacher training programmes is essential from time to time as a measure of their teaching potential. This would lead to many reforms or programmes that will help in pre-service teachers' preparations.

In a research involving fifty (50) student teachers recruited at random from three Colleges of Education in the Central and Western Regions of Ghana Enu et al. (2015) discovered that students accepted with excellent marks already had a solid foundation in mathematics. "Because learning is a cumulative process, a student accepted with greater entrance requirements will be better prepared for course content than one admitted with the basic minimal qualification" (Mlambo, 2011). But study by Gideon (2016) into University admission grades and academic achievement of students in University Course

Tests indicates that admission cut-off grade may not be a significant factor in influencing the rate of success in university examinations. Consequently, additional variables, such as students' social and emotional well-being, reading habits, and leisure activities, may influence accomplishment ratem (Ameyaw & Anto, 2018).

In contrast, research conducted by Schiefele and Csikszentmihalyi (1995) revealed that, of all the cognitive domain variables, past academic accomplishment is the most significant predictor of academic success on the American College Testing (ACT) in 2007. Murray (2013) conducted a research involving 132 students enrolled in the algebra course (MTH 111) at the Berbice Campus during the 2010-2011 and 2011-2012 academic years. The purpose of this research was to determine whether there was a significant correlation between students' past Caribbean Secondary Education Certificate (CSEC) mathematics achievement and their performance in MTH111. Murray (2013) found that moderate but positive correlation existed between MTH111 and CSEC Mathematics grade. Prior mathematical achievement in this research is defined as achievement exhibited at the Senior High School level or at a level deemed admissible to the College of Education program.

Mathematics self-efficacy is not only important for mathematics learning and accomplishment, but also for fostering student learning (Twohill et al., 2022). Self-efficacy is a person's confidence in their capacity to achieve in certain conditions. The academic part of this idea is known as academic self-efficacy and is defined as an individual's perception that he or she can effectively complete a certain academic activity at a specified level (Bandura et al., 1999). Mathematical self-efficacy is the notion that one's actions and efforts may lead to mathematics achievement (Luttenberger et al., 2018; OECD, 2013). Self-efficacy and value views, which in this instance pertain to the topic of mathematics, are strongly associated with academic accomplishment (Ardi et al., 2019). The bulk of research on self-efficacy has concentrated on the primary, junior, and high school years, which have been recognized as crucial for predicting success in the science, technology, english, biology, and mathematics disciplines (Ahmed et al., 2022; Semilarski et al., 2022; Tai et al., 2006; Wang & Lewis, 2022). Mathematics self-efficacy in adolescents is quite changeable (Arens et al., 2022; Hiller et al., 2022). Self-efficacy in mathematics has become a major justification for the study of psychological aspects in mathematical education. Studies examining the relationship between mathematics self-efficacy and mathematical performance have consistently shown a favorable link (Ayotola & Adedeji, 2009; Azar & Mahmoudi, 2014; Bonne & Johnston, 2016; Ramos Salazar, 2018). Self-efficacy was shown to be the strongest predictor of intrinsic motivation and tenacity in tough problem-solving situations (In'am & Sutrisno, 2021; Skaalvik et al., 2015; Yapo et al., 2021). The intrinsic motivation is the innate drive to do great things regardless of obstacles. In contrast, pupils with low mathematical self-efficacy suffer diminished motivation, which often leads to poor performance. Therefore, there is benefit in mathematics instructors' deliberate attention to their pupils' psychological experiences.

Özcan and Kültür (2021) discovered that mathematics self-efficacy may predict about fifty percent of the variance in mathematics success. In all nations, mathematics self-efficacy had the greatest impact on geometry and trigonometry success, outweighing both socioeconomic status and mathematics fear. Higher level of mathematics self-efficacy have been correlated with a speedier rate of progress in mathematics over time. There is a

positive and strong relationship between mathematics self-efficacy and the rapid change in general mathematics performance (Galla et al., 2014). Similarly, Jameson and Fusco (2014) investigations in 226 undergraduate students (traditional students and adult learners) reported lower self-confidence, lower mathematics self-efficacy and higher levels of mathematics anxiety particularly among adults' learners. High anxiety tends to negatively affects students' mathematics learning and achievement.

In addition, various classroom interventions have been investigated and shown to be effective. The treatment performed by Brisson et al. (2017) was concentrated on the utility of mathematics, and consisted of asking ninth-grade students to write down their ideas in response to quotations that were centered on the usefulness of mathematics. In addition, the students were given specific examples of the use of mathematics in a range of situations and occupations. The activity and written responses required just ninety minutes of class time, and the students were given two homework assignments as reinforcement. Significant improvements of 41 were reported in both self-efficacy and test scores, as well as increases in teacher-observed levels of effort, several months following the intervention (Brisson et al., 2017). According to the results of this study, students' perceptions of their ability to complete a mathematical task are known as mathematics self-efficacy (Bandura, 1993; Pajares & Kranzler, 1995), while in Geometry and Trigonometry, accomplishment is determined by the final grade, which takes into account not just classwork but also projects, presentations, and the final test.

This study's objective was to investigate the association between Pre-service teachers' past mathematics performance in senior high school and their learning and success in Geometry and Trigonometry. In addition, we explore the link between mathematics self-efficacy and the learning and success of pre-service teachers in Geometry and Trigonometry. This study would provide useful information on the relationship that exists between selected factors investigated and pre-service teachers' learning and achievement in Geometry and Trigonometry (EBS 143) in the Degree in Basic Education programme to mathematics policymakers in the Colleges of Education. It would also provide pre-service teachers at colleges of education with a method for developing and implementing intervention techniques, resulting in enhanced outcomes. At addition, it will allow pre-service instructors in colleges of education to adopt proactive steps in the acquisition of geometry and trigonometry.

METHOD

The study is a quantitative research and employed correlational research design to collect data in addressing the research questions. According to Check and Schutt (2012), survey is the collection of data from a sample of individuals through their responses to questions. It is also a method used for collecting data from a predefined group of respondents to gain information and insights on various topics of interest. Correlational research design is a procedure in quantitative research in which investigators measure the EBS 143 association or (relationship) between two or more variables or sets of scores (Creswell, 2012).

Population refers to the entire individuals or people or objects in which the researcher(s) is interested and to which the findings of the study is generalize. The population of the study was all level 100 pre-service teachers who enrolled in Geometry &

Trigonometry (EBS 143) during 2017/2018 academic year in the Volta Region Colleges of Education in Ghana. There are six public colleges in the Volta Region. The population of the six colleges was one thousand, three hundred and forty-three (1,343) of level 100 pre-service teachers. The population composed of (633) males representing (47.13%) and (710) females representing (52.87%). The distribution of the population for each college is represented in Table 1.

Table 1. Population for each college

College	Number of Males	Number of Females	Total
A	127	47	173
B	112	172	284
C	117	107	224
D	0	179	179
E	202	99	301
F	75	170	182
Total	633	710	1,343

Source: Institute of Education, UCC (2019)

The sampling procedure was purposive, stratified and simple random. The purposive sampling method was used to select the Colleges of Education for the study. Purposive sampling was used because the researchers could easily reach out to three colleges which is not so wide apart. Nonetheless, 3 out of 6 colleges may be considered representative of Volta colleges. In this study, stratified sampling was also used to obtain the gender balance. The pre-service teachers were first stratified into categories or strata: by gender or sex group (males and females). The stratified sampling was used because the researchers needed to have both genders in the sample. Simple random sampling technique was then used to select the pre-service teachers from the respective Colleges. The pre-service teachers in the selected colleges were gathered in their various colleges auditorium. A box containing a (YES and NO) pieces of paper was presented to them and they were required to pick a paper from the box randomly. All pre-service teachers that picked the yes pieces of paper were included in the sample and those that picked "NO" pieces of papers were not included in the sample.

Sampling is taking a portion of the population of a study as a representation of the entire population. The sample for the study was drawn from three (3) Colleges of Education namely; College A, College B, and College E. A sample of four hundred and forty-nine (449) representing 33.43% of the target 1,343 of the pre-service teachers was used for the study. The sample composed of 449 comprising 264 males and 185 females. The detailed distribution of the sample for each College is presented in Table 2.

Table 2. Distribution of the sample for each college

S/N	College	Total
1.	A	118
2.	B	162
3.	E	169
	Total	449

A sample of 118 was drawn from College A, representing 26.28% of the entire sample size. Also, a sample of 162 was drawn from College B, representing 36.08% of the sample size, while a sample of 169 was also drawn from College E representing 37.64% of all level 300 pre-service teachers.

Data from primary source were used to isolate influencers of EBS 143 (Geometry & Trigonometry) learning and achievement. The major source was a two-sectioned questionnaire with closed-ended, multiple-choice questions that were sent to pre-service instructors. While component A collected demographic information and past mathematical performance at the Senior High School (S. H. S.), the other sections elicited beliefs about mathematics self-efficacy. Pre-service teachers were expected to react to the mathematics self-efficacy claims using a variety of 5-point Likert scale styles ranging from strong agreement to strong disagreement. The researchers adapted questionnaire used by Belcheir (1997), Benford and Gess-Newsome (2006), Cherney and Cooney (2005), and Lee and Meletiou-Mavrontheris (2004) in a survey.

Creswell (2012) defined reliability of test instrument as the extent to which the test instrument consistently measures what it is supposed to measure. Reliability is also the extent to which results are consistent over time and if the results of the research can be reproduced under a similar methodology, then the measurement instrument is considered to be reliable. Tests of internal consistency indicated Cronbach Alpha indices of 0.78 mathematics self-efficacy.

In the process of data analysis, activities are conducted to summarize and arrange the field data obtained. Divergent opinions exist on the suitable statistical studies that might be performed on data acquired using Likert forms. Likert data received with a code from 1 - 5 is converted into continuous data by calculating the responses to statements that have been measured from each variable to obtain a subscore on that scale. This makes it possible to convert the resulting Likert scale data into intervals (Brown, 2011; Creswell & Creswell, 2017). In addition, the EBS 143 (Geometry & Trigonometry) achievement data collected consisted of pre-service teachers' composite scores on end-of-semester examinations and prior academic achievement data comprised of the grade students obtained at Senior High School (S. H. S) and categorized on a scale of 1 to 6 with 6 being the highest grade obtained, were treated as interval data. The Pearson Product Moment Correlation Coefficient (r) was then utilized to establish whether or not the correlations between the dependent and independent variables were statistically significant. Before analyzing the data, the missing values were substituted with the average score of the respondents' scale items (Wuensch, 2009).

RESULTS

Relationships between prior mathematics achievement and achievement in geometry and trigonometry

The result in Table 3 indicates that there was statistically significant strong positive correlation of $r = 0.543$ relationship between PA and EBS 143.

Table 3. Pre-service teachers' prior mathematics achievement at high school and pre-service teacher's learning and achievement in the Geometry and Trigonometry

Variable	Prior Mathematics Achievement	Geometry and Trigonometry Achievement Score
Prior Mathematics Achievement	1	0.543
Geometry and Trigonometry Achievement Score	0.543	1

* $P < 0.05$

As the relationship was positive at $p < 0.05$, it is possible that level grades of S.H.S. are connected to the performance of pre-service teachers in Geometry and Trigonometry. However, this relationship (0.543) was not very strong. This may be due to the fact that the prior mathematics achievement covers other areas of mathematics (Algebra, statistics) and is not specific to Geometry and Trigonometry areas only.

Mathematics self-efficacy and geometry and trigonometry achievement

Calculating the Pearson correlation coefficient, Table 4 revealed a substantial association between self-efficacy in mathematics and their performance on EBS 143. Table 4 shows a moderately positive correlation of $r = 0.542$ at a significance level of $p < 0.05$.

Table 4. Results of correlation (r) between mathematics self-efficacy and pre-service teachers learning and achievement in geometry and trigonometry

Variable	Mathematics Self-efficacy	Geometry and Trigonometry Achievement Score
Mathematics Self-efficacy	1	0.542
Geometry and Trigonometry Achievement Score	0.542	1

Correlation is significant at the 0.05 level (2-tailed)

The result in Table 4 indicates that there was statistically significant strong positive relationship between $MSEf$ ($r = 0.542$), and EBS 143. The correlations were significant because they were different from zero in the entire/total population.

DISCUSSION

Relationships between prior mathematics achievement and achievement in geometry and trigonometry

In our aim to have effective teachers who will promote effective learning and deepen preservice teachers' geometry and trigonometry knowledge we would have to pay attentions to their prior mathematics achievement to inform our lessons planning and enactment. This study point to positive relationships between prior mathematics achievement in high school and geometry and trigonometry course achievement in teacher training institution. This relationship suggests that pre-service teachers who demonstrated

good knowledge of mathematics prior to their college entry would have more content knowledge than those who do not and as such are likely to be effective teachers who will promote mathematical literacy in their learners.

This finding is consistent with the findings of (Murray, 2013) that prior academic mathematics achievement influences academic achievement. Furthermore, Hemmings et al. (2011) and Kyttälä and Björn (2010) have also found relationship between prior mathematics achievement and students' academic ability. This relationship may have to do with students' conceptual understanding of concepts taught at high school. Also, this is supported by Anderton et al. (2017) who found student's grade point average a good predictor of their achievement in mathematics course. This implied that pre-service teachers' mastery of mathematical concepts at senior high school is crucial for their competency in geometry and trigonometry. This will intend translate to quality teacher preparations. Policymakers should be interested in effective teaching and learning of mathematics at high and primary schools since it has implications for their further studies. However, the results disagreed with research by Gideon (2016) finding that no significant relationship exist between student's high school grade and their performance in university course grade. Further research is needed in various programme studied at high school and how they relate to various programmes at tertiary level. The clarity on this will serve as a guide for high school graduate on the choice of programme to be read at the universities or colleges. Similarly, this has implications for admission requirement.

Mathematics Self-efficacy and Geometry and Trigonometry Achievement

Previous research reveals that there are correlations between mathematics self-efficacy and mathematics accomplishment; however, there is insufficient data on the relationships between mathematics self-efficacy and geometry and trigonometry course achievements in college. This study's findings are consistent with several previous reports.

The positive relationship between mathematics self-efficacy and Geometry and Trigonometry course achievement, could imply that pre-service teachers would perform better in Geometry and Trigonometry course if they have higher mathematics self-efficacy. The results suggested that as mathematics self-efficacy increased pre-service teachers' performance in Geometry and Trigonometry course also increased and conversely, as mathematics self-efficacy decreased, achievement in Geometry and Trigonometry course decreased. The findings of this study is consistent with the findings of Onyeizugbo (2010) that a positive correlation exists between self-efficacy and academic achievement. The findings also aligned with Bonne and Johnston (2016), and Skaalvik et al. (2015) that there is a strong relationship with self-efficacy and student achievement in mathematics. This imply that pre-service teachers with higher mathematics self-efficacy would have higher retention rates.

Pre-service teachers need to be motivated and inspired by academic counselors and lecturers to improve performance in Geometry and Trigonometry. Such inspirations should target the mathematics self-beliefs of pre-service teachers. Pre-service teachers' confidence can be improved through environmental variables such as conducive college environment and work responsibilities. Also, time spent on learning, tutoring assistance, innovative teaching and creative teaching may also deepen pre-service mathematics teachers' self-efficacy. However, the finding contradicted with that of Hailikari et al. (2008) who found

that students' self-perception of their own academic abilities had little impact on their performance in the course. It is unclear what might account for this contradiction.

CONCLUSION

In this study, we examined the relationships between pre-service teachers' prior mathematics achievement at high school and mathematics self-efficacy on learning and achievement in Geometry and Trigonometry at college of education in Ghana. The study found strong relationships between pre-service teachers' prior mathematics achievement and learning and achievement in Geometry and Trigonometry course (EBS 143). We also examined the relationships with mathematics self-efficacy and achievement in geometry and trigonometry course. In this regard, moderate relationships were found to exist with mathematics self-efficacy and achievement in Geometry and Trigonometry course. With reference to the findings of the study the researchers therefore conclude that the pre-service teachers' prior mathematics achievement and mathematics self-efficacy have a strong positive relationship with pre-service teachers learning and achievement in Geometry and Trigonometry course and should be duly considered.

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