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PRE-SERVICE TEACHERS PERFORMANCE IN GEOMETRY IN THE COLLEGES OF EDUCATION, GHANA

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Keywords

Mathematics, Geometry, pre-service teachers.

Abstract

Studies indicate that geometry enables pre-service teachers to link mapping objects in the classroom to real-life situations. Additionally, studies indicated that the proficiency development of the participants is a challenge. The study investigated participants' performance in geometry, and by gender. Also, the study looked at how students' performance in geometry is a predictor for proficiency development of pre mathematical knowledge for teaching among the prospective teachers. Findings revealed that participants have difficulties in solving geometry concepts, male participants outperformed their female counterparts, and about 25% of them are likely to display potential early proficiency in their mathematical knowledge for teaching.

Backgrounds to the study

Mathematics involves the study of quantity, space, change, and structure. Mathematics involves the use of patterns to formulate new conjectures, resolve the doubt of mathematical proofs. According to American Heritage Dictionary (2000), Mathematics deals with the study

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of numbers, symbols, measurement, properties, relationships of quantities, and sets of numbers. Further, the Encyclopedia Britannica (2012) has explained mathematics to be a science of structure, relationships that have been generated from elemental practices of measuring, ordering, counting, matching, and identifying the shapes of objects.

Students in the colleges of education study many aspects of mathematics in the colleges of education curriculum such as algebra, calculus, and geometry. Limited time did not allow the researchers to investigate pre-service teachers' performance in all these areas of mathematics. The study assessed participants' performance in geometry concepts. According to Vesely and Vesely (2015), geometry deals with the study of the geometric characteristics of a figure that cannot be changed when the size of the figure is transformed. Some of these geometric characteristics include lines, points, and lengths. Geometry is a branch of mathematics that deals with properties of space that are related to the shape, distance, size, and relative position of figures (Naidoo & Kapofu, 2020). Geometer is the name given to the mathematician who works in the field of geometry. The study of geometry is vital because these characteristics are found in the human body to be specific and within our environment in general.

We use geometry every day in our activities. Geometry helps to develop learners thinking abilities. Further, geometry enables pre-service teachers to link mapping objects in the classroom to real-life situations such as place and direction. Comprehension of spatial relationships is an advantage in the role of problem-solving and higher-order thinking skills. Geometry assists us to choose the type of material to use, the type of design to make in the construction process. Different houses are built in different geometric shapes. According to Sunzuma et al. (2012), geometry develops learners' spatial awareness, visualization, and promotes learners' problem-solving skills. Again, geometry develops learners' critical thinking and problem-solving skills (Pesen, 2006) as cited in (Kakraba, 2020).

Despite the importance of geometry in our everyday activities, students still perceive geometry as a challenging subject. Globally, Mafakheri (n.d.) assessed pre-service teachers' performance in geometry. The study was conducted in Iran. Results revealed that most pre-service teachers have difficulties understanding concepts of the symmetry axis. This could be

because students could not visualize and conceptualize geometric concepts. As Bhagat and Chang (2015) have convincingly shown in their research, students perceive geometrical concepts as abstract and difficult to understand.

In Africa, Niyukuri et al. (2020) assessed university students' experiences in learning geometry and their confidence to teach it. The study used a convergent parallel mixed methods research design. Results showed that the teacher-centered approach had dominated geometry lessons in their mathematics classrooms. Nevertheless, pre-service teachers indicated a higher level of confidence teaching geometry in mathematics classrooms. The study suggested that teacher education programs consider embedding instructional techniques and assessments designed for a specific branch of mathematics.

Further, Adeniji et al. (2018) looked at the effect of mastery learning on high school students' performance and retention in circle geometry. The study was conducted in Ilorin using a quasi-experimental design. More specifically, the study used a non-equivalent (pretest and posttest) control group design. The results indicated that high school students' achievement in geometry had improved significantly when students were taught circle geometry with mastery-based learning techniques. Indirectly, the mastery-based learning method had played a role in helping students to understand geometry concepts. Findings further revealed that there was no gender difference found when the participating students were taught circle geometry using the said method. The study suggested that training should be given to mathematics teachers to effectively use the mastery-based learning technique in the mathematics classroom to facilitate learners' achievement. The study was conducted on high school students leaving out colleges of education students. To address this gap, the present study focused on basic pre-service teachers in colleges of education.

In Ghana, pre-service teachers' achievement in geometry in the colleges of education over the years has not shown any improvement despite the introduction of technology in 2008 (Agyei & Voogt, 2012). In addition, Armah et al. (2018) assessed the effect of Van Hiele Phase-based instruction on secondary pre-service teachers' geometric thinking concerning the Van Hiele Levels in the Ashanti and Greater Accra Regions. The study used a quasi-experimental design. The results indicated that students in both the experimental and control groups had an

increment in the post Van Hiele geometry test as compared to the pre-Van Hiele geometry test. However, students in the experimental group achieved higher scores as compared to their counterparts in the control group. The computer-based learning method used on the experimental group might have played a role in making geometry concepts clearer for students understanding. This study was conducted on university students. The researchers suggested that studies should be conducted on pre-service teachers' achievement in geometry in the colleges of education. In view of this, the present study investigated basic pre-service teachers' achievement in geometry at the college level of education.

Many studies including (Niyukuri et al., 2020; Adeniji et al., 2018) have been conducted on pre-service teachers of secondary school leaving their counterparts at the basic level of education. This study addressed that gap by investigating pre-service teachers' performance in geometry in the Colleges of Education. This study aimed to get quality feedback from the students' achievement in geometry to add to the existing literature. Further, the present study investigated gender differences among students' performance in geometry. Again, the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers was assessed.

Statement of the problem

Geometry is important in our everyday activities. Geometry helps to develop learners thinking abilities. Further, it helps pre-service teachers to connect classroom mapping objects to situations in real-life such as direction and place (Yuin et al., 2020). The participating students' comprehension of spatial relationships plays a role in problem-solving and higher-order thinking skills.

However, the national report in Ghana since 2013 has consistently highlighted pre-service teachers' low performance in geometry. Additionally, international studies indicate that student teachers perceive geometry concepts as abstract and challenging in conceptualization leading to low achievement.

In Ghana, no research has been conducted on college students to describe such low achievement in geometry. This study sought to investigate basic pre-service teachers' achievement in geometry in the Ghanaian Colleges of Education.

Objectives

This paper was guided by the following objectives:

a) To assess basic pre-service teachers' achievement in geometry.
b) To investigate gender differences among basic education pre-service teachers' performance in geometry.
c) To assess the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers.

Methodology

The study used quantitative data using a survey design. This study was carried out in Presbyterian College of Education (PCE) in Ghana because of academic affordances (such as availability of teaching and learning resources, and conducive environment for learning). The study targeted all the level one hundred students in PCE. The target population of the study was made up of 493 first-year students in the said college of which 313 were males and 180 were females. The researchers used a purposive sampling procedure to select an intact group consisting of 400 participants of which 223 were males and 177 were females. This group was selected because they all offer the same program.

The researchers sought for permission through the principal of Presbyterian college of Education to enable them collect data in this institution. See Appendix 'B' for Research permit. Data was collected using secondary data in the form of geometry achievement test results from the Presbyterian College of Education for first-year students' second-semester examination for the 2019/2020 academic year. See Appendix 'A' for students' geometry achievement test result. Again, see Appendix 'C' for the grading system and interpretation of the grades for colleges of education in Ghana. The first-year students were selected for this study because geometry is a first-year content course that is taught in the second semester. The data was analyzed using Statistical Package for Social Sciences (SPSS) version 24. Descriptive statistics such as frequencies, percentages, mean and standard deviation were

used to analyze students' performance to answer research question one (1). The researchers used inferential statistics such as independent samples t-test to analyze gender difference in pre-service teachers' performance in geometry to answer research question two (2). The t-value was estimated at a significance level (p-value) of $p \leq 0.05$ (2 – tailed) at a confidence interval of 95% with a margin of ±5. Finally, the study used descriptive statistics such as frequencies and percentages to analyze the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers to respond to research objective three (3).

Results and Discussions

In this section, the results were presented as follows: (i) Pre-service teachers of basic school performance in geometry. (ii) Explored gender differences among pre-service teachers' performance in geometry. (iii) Effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers. Table 1 presented the demographic information of the pre-service teachers.

Table 1: Demographic analysis

Sex	N	Percent
Male	223	55.8
Female	177	44.3
Total	400	100.0

Table 1 revealed that 223 pre-service teachers are males representing 55.8%. On the other hand, 177 pre-service teachers are females representing 44.3%. In this study, the males are more than the females by 11.5%.

Research objective 1: To assess pre-service teachers' performance in geometry

The study sought to investigate the participating students' achievement in geometry. This was to enable the researchers to get in-depth information concerning pre-service teachers'

performance in geometry. The performance of the participants in geometry achievement test is presented in Table 2.

Table 2: Pre-service teachers' performance in geometry

Grade	N	Percent
E	43	10.8
D	86	21.5
D+	60	15.0
C	61	15.3
C+	40	10.0
B	39	9.8
B+	35	8.8
A	25	6.3
IC	11	2.8
Total	400	100.0

Table 2 presents the analysis of test results from the Presbyterian College of Education (PCE) for level one hundred second-semester examination for the 2019/2020 academic year on geometry. See Appendix 'C' for the grading system and interpretation for the colleges of education in Ghana. The results revealed that only 25 pre-service teachers representing 6.3% scored grade ''A'' (scores from 80% to 100%) at the end of the semester examination. About three – quarters of the pre-service teachers representing 18.6% scored grades 'B' and 'B+' (scores from 70% to 79%). Out of the 400 participants who wrote the semester examination on geometry, only about one-quarter of pre-service teachers representing about 25% scored grades 'A', 'B+', and 'B' (scores from70% to 100%). Further, the study showed that about one-quarter of the pre-service teachers representing about 25% scored grades 'C' and 'C+' (scores from 60% to 69%). More than one-quarter of the pre-service teachers representing about 37% scored grades ''D'' and ''D+" (scores from 50% to 59%). As many as 43 (about one-tenth) representing about 11% of the participants scored grade ''E'' (scores less than 50%). Grade ''E''

is interpreted as failure. The pass mark for the geometry achievement test is 50%. Again, the analysis indicated that as many as 11 (about 3%) had IC. The IC means incomplete and is interpreted as students having issues with the examination as a result of non-submission of assignments. See Appendix C for the grading system and the interpretation of grades in the colleges of education in Ghana.

This performance in geometry achievement test is not good because about one-tenth of the participants representing about 11% did not get the pass mark of 50%. This shows that students have difficulties with geometry concepts. This could be because students perceive geometry concepts as difficult. This study is related to Bozkurt (2018) who examined Turkish elementary grade pre-service teachers accuracy for geometric constructions with dynamic software, students' justification for accuracy of geometric figures, and the awareness they gained throughout the process. The results indicate that the participants' achievement in geometric concepts was limited.

Further, the finding of Duatepe-paksu and Levels (2012) is in agreement with the finding of the present study who state that geometry concepts are challenging among pre-service elementary teachers in Turkey. The study investigated factors that predict students' knowledge in geometry. The results showed that most Turkish pre-service teachers have weak knowledge of geometric concepts.

Similarly, Couto and Vale (2013) investigated Portugees secondary pre-service mathematics teachers' performance in geometry. The study reported that most participants have weak content knowledge of geometry in Portugal. Indirectly, students struggled to solve problems concerning geometry. Further, the findings revealed that many secondary pre-service teachers struggled to answer items regarding circular units of geometry to be specific during their undergraduate studies. This finding by Couto and Vale (2013) is in line with the findings of this study. This could be because students have similar characteristics everywhere. Further, the poor performance of the present study could be due to the voluminous nature of the course outline for college geometry. This could make teachers concentrate on completing the course outline at the end of the semester instead of teaching for the understanding of the geometry concepts. This poor performance might affect pre-service teachers' careers and

future learners. We suggest that pre-service teachers should work in groups so that they can share ideas. Further, pre-service teachers should constantly practice geometry concepts on their own to enhance understanding.

Research objective 2: To investigate gender differences among pre-service teachers' performance in geometry

In assessing research objective 2, the investigators examined gender differences among college students' performance in geometry. Pre-service teachers' performance in geometry concerning gender was presented as follows:

a) Pre-service teachers' performance in geometry concerning gender using frequencies and percentages.
b) Comparative analysis of pre-service teachers' gender performance in geometry using mean and standard deviation.
c) Looking at gender differences on pre-service teachers' performance in geometry using Independent Samples T-Test.

a) Pre-service teachers' performance in geometry concerning gender using frequencies and percentages

The researchers of this study investigated pre-service teachers' performance in geometry concerning gender using frequencies and percentages. The results are presented in Table three (3).

Table 3: Grade scored by students * sex of the students' cross-tabulation

		Sex of the students		
		Male	Female	Total
Grade scored by students	E	21	22	43
	D	36	50	86
	D+	37	23	60
	C	38	23	61
	C+	22	18	40
	B	22	17	39
	B+	23	12	35
	A	16	9	25
	IC	8	3	11
Total		223	177	400

From Table 3, the highest grade is ''A'' (scores from 80% to 100%). As many as 16 male pre-service teachers scored grade ''A'' as compared to only 9 of the females scoring it. As many as 23 males scored grade ''B+'' while only 12 females scored grade ''B+'' (scores from 75% to 79%). The number of male students who scored grade ''B'' is 22 while 17 of their female counterparts' scored 'B' (Scores from 70% to 74%). As many as 60 male pre-service teachers scored grades 'C' and 'C+' (scores from 60% to 69%) as compared to only 41 of their female counterparts'. A look at Table 3 revealed that 73 each of the gender scored grades 'D' and 'D+' (scores from 50% to 59%). Further, 21 and 22 males and females respectively scored grade ''E'' (scores less than 50%) which is interpreted as a failure. An examination of Table 3 showed that 8 males and 3 females had issues (IC) with their results. The results indicated that though both males and females have difficulties in geometry concepts, the males scored higher scores than the females. It makes sense to state that the male pre-service teachers outperformed their female counterparts'.

The performance of male pre-service teachers in geometry is slightly higher than their female counterparts'. Table 3 revealed that 61 male pre-service teachers are above average (grades

A, B+ and B) and are likely to be good mathematics teachers as compared to their female counterparts of 33. Further, as many as 60 male pre-service teachers are average (grades C+ and C) and are likely to be average mathematics teachers as compared to only 41 female pre-service teachers. However, there is no difference between male and female participants who are below average (grades D+ and D) and may need guidance to manage mathematics classes. See Appendix C for the grading system.

The findings of Isiksal (2005) are in contrast to the findings of this study who investigated the effects of gender and year in the programme on the performance in geometry among 145 pre-service teachers in Turkey. The findings revealed that Turkish female pre-service teachers scored significantly higher than their male counterparts' on performance. This indicates that when both males and females are given equal opportunities in the teaching and learning of mathematics, the females can perform and even better than the males. Therefore, mathematics teachers should give equal opportunities to both males and females in the mathematics classroom. Further, mathematics teachers should create a conducive atmosphere for all learners.

Tetteh et al. (2018) investigated gender differences in mathematics achievement among Pre-service Teachers in the Bono Region of Ghana. Results revealed that there was a significant gender difference in participating students' achievement. However, the study did not indicate the group where the difference was favored. Further, the study focused on mathematics in general and could be that geometry topics may or may not be included in the test items.

b) Comparative analysis of pre-service teachers' gender performance in geometry using mean and standard deviation

The study sought to compare college students' performance in geometry in terms of gender. The researchers of this study conducted a comparative analysis using mean, standard deviation, and standard error mean. The analysis was done using the grade points as indicated in Appendix C. As indicated in Appendix C, 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 presented in Table 4.

Table 4: Comparison of pre-service teachers' gender performance in geometry using mean and standard deviation

	Sex of the students	N	Mean	Std. Deviation	Std. Error Mean
Grade scored by students	Male	223	2.121	1.2398	.0830
	Female	177	1.805	1.1883	.0893

Table 4 presents the comparison of students' performance in geometry in terms of gender. As indicated in the table 4 above, the Grade Point Average (GPA) score of the males is 2.121(Grade C+ = scores from 65% to 69%) and that of the females is 1.805 (Grade D+ = scores from 55% to 59%). The mean score of the males is higher than that of the females indicating that the male pre-service teachers scored higher marks than their female counterparts'. The findings of Mutai et al. (2016) are in support of the findings of the present study. The study looked at gender differences in mathematics achievement among secondary school students in Kenya. Results indicated that boys outperformed the girls. Further, boys showed a strong affinity and interest in mathematics. However, the study by Mutai et al did not base purely on geometry rather on mathematics in general. The test items that were shown on the journal paper were only statistics and probability questions. There was no geometry question. However, the findings of Seloraji and Eu (2017) are in contrast to that of the present study who investigated Malaysian pre-service teachers' achievement in geometrical concepts using GeoGebra. The results of Seloraji and Eu indicated that there was a significant difference in the scores between male and female students favoring the females. The study of Seloraji and Eu reported a mean score of 86.00 for the female which is above that of the male score of 68.33.

In Table 4, the standard deviation of the males is 1.2398 and that of the females is 1.1883. This indicates that though the male pre-service teachers scored higher marks than the

females, male marks are more spread over the mean mark than the females. Therefore, the performance of the females is better than that of the males. Finally, the standard error mean of the males is 0.0830 as compared to that of the females (0.0893). The standard error of the females is slightly above that of the males. The results showed that the males are more representative of the overall population than the females. The smaller the standard error, the more representative the sample will be of the overall population (Mugenda & Mugenda, 2019).

c) Looking at gender differences on pre-service teachers' performance in geometry using independent samples t-test

This research sought to assess the gender differences in pre-service teachers' performance in geometry. The comparison was made using a p-value, and a significant level of 0.05. The analysis was done using the Grade Point Average (GPA) of students' achievement in geometry. The comparison is presented in Table 5.

Table 5: Gender difference on pre-service teachers' performance in geometry

Independent samples t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Grade scored by students	Equal variances assumed	.138	.711	2.579	398	.010	.3160	.1225	.0751	.5569
	Equal variances not assumed			2.591	384.16	.010	.3160	.1219	.0762	.5558

The results in Table 5 showed that the group means are statistically significant differences between male and female group scores in geometric concepts because the significance (2-tailed) value is 0.01 which is less than 0.05. The researchers conducted an independent-samples t-test to establish the significance of the difference between gender in the geometric scores. The result showed that there was a significant difference in the scores for female (Grade Point Average (GPA) = 1.805, SD = 1.188) and male (Grade Point Average (GPA) = 2.121, SD = 1.240) conditions; t (398) = 2.579, p = 0.010. See Appendix C for the grading system and their interpretation.

In addition, the findings revealed that there was a mean difference of 0.3160 between male and female participants' performance in geometry favoring the males at 398 degrees of freedom. The mean difference (0.3160) indicates that the male students (GPA = 2.121) outperformed their female counterparts (GPA = 1.805) in the population from which the sample is selected. The finding of Seloraji and Eu (2017) is in contrast to that of the present study who investigated Malaysian pre-service teachers' performance in geometry concerning gender. The result revealed that the female students (mean score = 87.00) outperformed their counterparts' male students (mean score = 68.33) giving the mean difference of 17.667. This shows that the female students scored better than the male students from the population in which the sample is drawn.

Further, the findings of Arigbabu and Mji (2004) are in contrast to the findings of the present study who investigated Nigerian graduating pre-service teachers' mathematics performance over 3 years and examined their gender differences. The results indicated that there are no gender differences between pre-service teachers' performance in geometry. It makes sense to conclude that both male and female pre-service teachers are capable of competing in the teaching and learning of geometry concepts. We recommend that both groups should pay attention in class during the teaching and learning process. Pre-service teachers should constantly practice geometry concepts to be specific and mathematics in general.

Research objective 3: To assess the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers.

The study sought to assess the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers. This was to enable the researchers to get in-depth information concerning pre-service teachers to predict their teaching proficiency. The performance of the participants in geometry is presented in Table 6.

Table 6: Grade scored by students concerning gender

		Sex of the students		
		Male	Female	Total
Grade scored by students	E	21	22	43
	D	36	50	86
	D+	37	23	60
	C	38	23	61
	C+	22	18	40
	B	22	17	39
	B+	23	12	35
	A	16	9	25
	IC	8	3	11
Total		223	177	400

A look at Table 6 revealed that only about one-quarter of the participating students scored grades (A, B+, and B) and are described as above-average pre-service teachers. This indicates that about one-quarter of the pre-service teachers representing about 25% are likely to display potential early proficiency in their mathematical knowledge for teaching. Further, slightly more than one-quarter of the pre-service teachers scored grades (C+ and C) and are described as average pre-service teachers. This shows that about 25% of the participants are likely to be average mathematics teachers. More than one-quarter of the pre-service teachers representing about 37% scored grades (D+ and D) and are described as below average pre-service mathematics teachers. This indicates that about 37% of them are likely to display low

proficiency development in mathematical knowledge for teaching. According to the study, as many as 43 pre-service teachers representing about 11% scored grade E and may require support to manage mathematics classes.

A careful look at the results indicated that we are likely to have few mathematics teachers who can display potential proficiency in their mathematical knowledge for teaching. The majority of the college students are likely to show low proficiency development in mathematical knowledge for teaching. If the situation is not looked at, by ten years to come we are likely not to get teachers who can teach geometry and mathematics as a whole. This is likely to affect college students' careers, learners' achievement, and the nation as a whole.

Further, the findings revealed that out of the 400 pre-service teachers 61 male participants are likely to display potential early proficiency in their mathematical knowledge for teaching as compared to only 38 of their female counterparts. Averagely, there are 60 and 41 male and female participants respectively. However, there is no difference in number between below-average male and female pre-service mathematics teachers. If this trend continues by twenty years, we are likely to have very few female mathematics teachers. Further, we are likely to have teachers who lack the concepts of geometry and will not be able to teach geometry. This is supported by Harding and Hbaci (2015) who investigated pre-service teachers' mathematics teaching experience. The study suggested that pre-service teachers in this era need to grasp geometry concepts rather than memorize formulae. This is vital for them to further their knowledge in geometry to enable them effectively teach geometry to be specific and mathematics in general.

Summary of findings

The findings of this study have been stated in terms of the study objectives. The first objective wanted to assess pre-service teachers' performance in geometry. To respond to this, the researchers analyzed the data using descriptive statistics from SPSS. Findings revealed that students in the Colleges of Education have difficulties in solving geometry concepts.

The second objective sought to investigate gender differences among the said participants' achievement in geometry using the independent samples t-test. The results showed that there was a statistically significant difference between males' and females' achievement in geometry achievement test favoring male students.

The third objective wanted to assess the effect of performance on the development of pre mathematical knowledge for teaching proficiency among basic education of prospective teachers. The study showed that only about one-quarter of the pre-service teachers representing about 25% are likely to display potential early proficiency in their mathematical knowledge for teaching. Further, slightly more than one-quarter of the pre-service teachers are likely to be average mathematics teachers. Again, more than one-quarter of the pre-service teachers representing about 37% are likely to display low proficiency development in mathematical knowledge for teaching. Eleven percent of them according to the study may require support to manage mathematics classes.

Conclusion

The analysis of objective one (1) of this study implies that college students have difficulties in solving geometrical concepts. The analysis of objective two (2) using independent samples t-test statistics indicated that there was a statistically significant difference between males' and females' performance in geometry achievement test favoring male students. Finally, the analysis of objective three (3) indicates that only about 25% of college students are likely to display potential early proficiency in their mathematical knowledge for teaching while about 37% of them are likely to display low proficiency development in mathematical knowledge for teaching. About eleven percent of them according to the study may require support to manage mathematics classes. Based on the conclusion mentioned above, college lecturers should therefore pay particular attention to the subject geometry when teaching it by relating concepts to real-life situations and giving equal opportunities to both males and females to practice the subject. Further, pre-service teachers should pay attention in the teaching and learning process, solve geometric problems in groups to share ideas, and constantly practice the subject to enhance understanding of geometric concepts.

Recommendation

The current study only focused on basic pre-service teachers' performance in geometric concepts, leaving other strands in mathematics. The study recommended that research works should be done to investigate pre-service teachers' performance on other strands in mathematics. Further, research works should be done to investigate pre-service mathematics teachers' pedagogical content knowledge in teaching geometry. Research works should be conducted to investigate the entry behaviors of pre-service teachers to find out which students should be admitted to offer geometry. Finally, this study recommends that pre-service teachers should utilize their time well, stick to schedules, and should not procrastinate in solving geometrical concepts. This will enable them effectively learn geometrical concepts with understanding.

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Appendix A: Pre-service Teachers Results in Geometry

Student ID	Gender	Grade	Student ID	Gender	Grade	Student ID	Gender	Grade	Student ID	Gender	Grade
1	F	B+	41	M	C	81	F	D+	121	F	C
2	F	B+	42	M	D	82	M	C+	122	M	E
3	F	B	43	M	D+	83	F	D	123	M	E
4	F	D	44	F	B+	84	M	B+	124	M	E
5	F	E	45	M	D+	85	F	D+	125	M	C
6	M	IC	46	M	D+	86	M	B	126	M	B
7	F	C	47	F	B	87	M	B+	127	M	D+
8	M	D	48	M	D+	88	F	C+	128	F	E
9	F	D	49	M	C	89	F	C+	129	F	E
10	M	C	50	M	B+	90	F	C	130	M	C+
11	M	D	51	F	C+	91	F	D+	131	M	B
12	M	D+	52	M	B+	92	M	B+	132	M	D
13	M	B	53	M	C	93	M	D	133	M	C
14	M	C	54	M	C+	94	F	A	134	M	E
15	M	C+	55	F	E	95	M	B+	135	M	C
16	M	D+	56	M	C+	96	M	C	136	F	D+
17	F	D+	57	M	D+	97	M	E	137	M	D
18	F	B+	58	M	B	98	M	D	138	M	D
19	M	B+	59	F	E	99	F	D+	139	F	D
20	F	E	60	M	C+	100	M	B	140	M	B+
21	M	D	61	M	D	101	M	D	141	M	A
22	M	D	62	F	D	102	F	C	142	M	C
23	M	D	63	M	C	103	F	D	143	F	D
24	M	C	64	M	D	104	F	D+	144	M	C
25	F	A	65	F	E	105	M	C	145	F	E
26	M	C	66	M	D	106	M	B	146	F	D
27	F	B	67	M	C+	107	F	C	147	F	C+
28	F	E	68	M	IC	108	F	D	148	F	C+
29	F	C	69	M	C	109	M	B	149	M	D+
30	M	C+	70	F	C	110	M	D	150	F	B+
31	M	C	71	F	E	111	M	C+	151	M	C+
32	F	C	72	M	D+	112	F	D+	152	F	E
33	M	B+	73	F	A	113	M	E	153	M	D+
34	M	D	74	F	B+	114	F	E	154	F	C
35	F	D+	75	M	A	115	M	C	155	F	C+
36	M	A	76	M	B	116	F	C	156	F	E
37	M	B+	77	M	D+	117	M	A	157	M	D
38	M	C	78	M	D	118	F	D	158	M	B
39	F	D	79	M	D	119	F	D+	159	F	A
40	F	D	80	M	C+	120	F	E	160	F	D

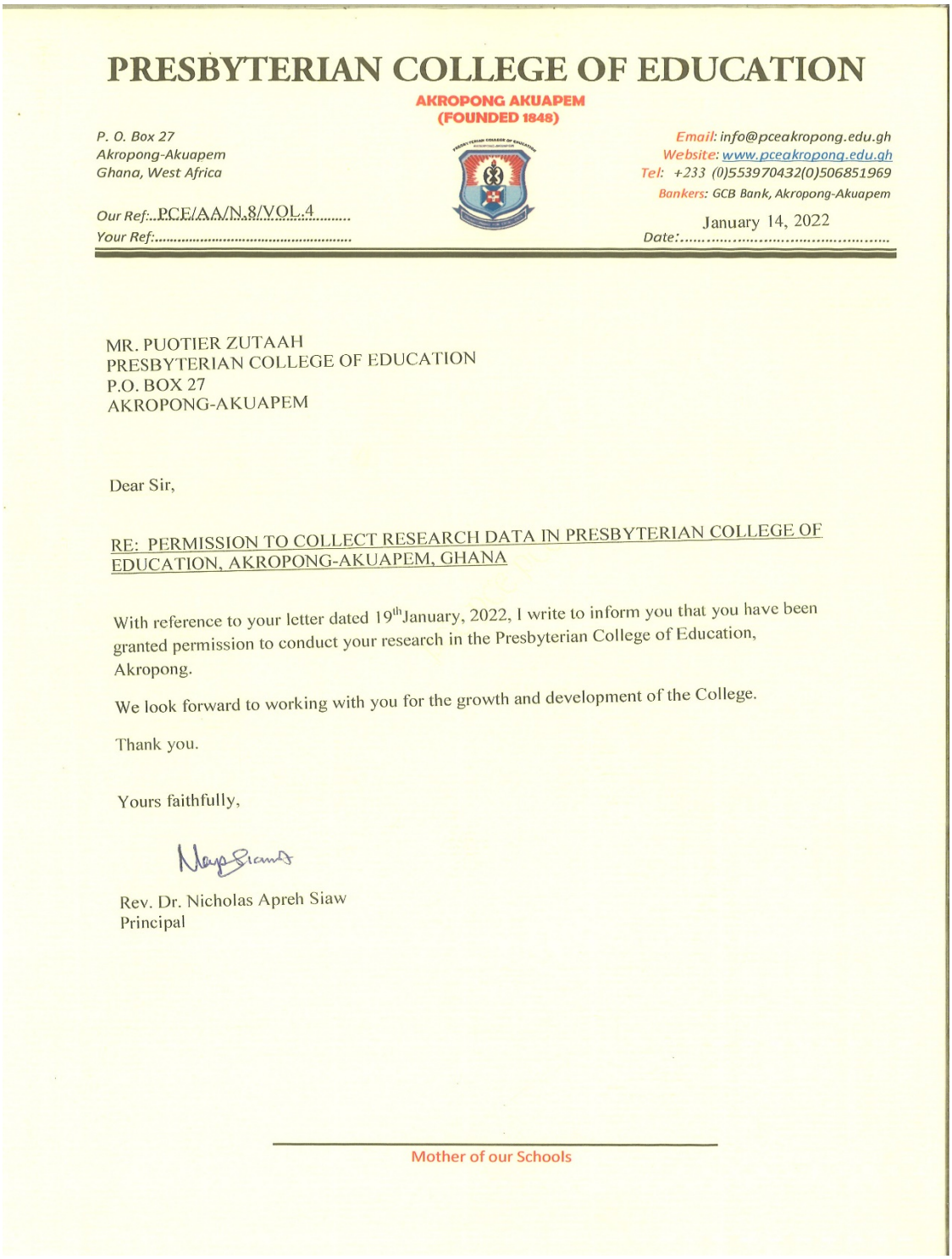
Student ID	Gender	Grade	Student ID	Gender	Grade	Student ID	Gender	Grade	Student ID	Gender	Grade
161	F	E	201	F	B	241	F	C+	281	M	D
162	F	D	202	F	D	242	M	C	282	M	B
163	M	B+	203	M	IC	243	M	D+	283	M	B+
164	F	D	204	M	B	244	F	A	284	F	D+
165	M	E	205	F	D	245	M	D	285	F	B+
166	M	D	206	F	C+	246	F	D+	286	F	C
167	M	D+	207	M	E	247	M	D	287	M	D+
168	F	D+	208	F	E	248	F	A	288	F	E
169	F	D	209	M	C	249	M	C	289	F	C
170	M	C+	210	M	D+	250	M	D	290	M	C
171	F	B+	211	M	C+	251	M	E	291	F	B
172	F	D	212	F	B+	252	F	D	292	F	D
173	M	E	213	F	E	253	F	A	293	F	D+
174	F	D	214	F	D	254	F	D	294	F	C+
175	F	D	215	F	D	255	M	B	295	F	B
176	M	E	216	F	D+	256	M	B+	296	M	D
177	F	C+	217	M	C	257	M	E	297	M	D+
178	M	E	218	F	D	258	M	B	298	M	C+
179	M	A	219	F	D	259	M	C	299	F	C
180	F	D	220	E	F	260	F	E	300	M	D
181	M	B	221	M	D+	261	F	C	301	F	D+
182	M	D+	222	M	C	262	F	D+	302	F	C+
183	F	B	223	M	C+	263	M	D	303	M	C
184	F	C+	224	M	D+	264	M	IC	304	F	D
185	M	D+	225	F	D+	265	F	D	305	F	D+
186	F	D+	226	F	B	266	M	C	306	M	D+
187	M	E	227	F	E	267	F	D+	307	F	IC
188	F	D	228	F	B	268	F	A	308	M	E
189	F	D	229	M	B+	269	F	D+	309	F	E
190	F	C	230	M	D	270	M	C+	310	M	E
191	M	C	231	M	D+	271	M	A	311	M	E
192	M	C	232	F	C+	272	M	D+	312	M	D
193	M	C	233	M	A	273	F	C	313	M	C
194	M	C+	234	F	C	274	M	B+	314	M	A
195	F	B	235	M	C	275	F	D	315	M	C
196	M	C	236	M	A	276	F	B	316	F	D+
197	M	A	237	M	IC	277	M	E	317	M	D+
198	F	B+	238	F	D	278	M	C+	318	M	B
199	M	B	239	F	D	279	F	IC	319	M	B+
200	M	A	240	M	E	280	F	D	320	F	D

Student ID	Gender	Grade	Student ID	Gender	Grade
321	M	C	361	M	B
322	F	B	362	M	C
323	M	C+	363	F	D
324	F	A	364	F	C+
325	M	IC	365	F	E
326	M	B	366	M	C+
327	M	D+	367	M	D
328	M	B+	368	F	D
329	M	E	369	M	A
330	F	B+	370	M	D
331	F	C+	371	F	C
332	M	C	372	M	B+
333	M	D+	373	M	B
334	F	D	374	M	A
335	M	C+	375	F	B
336	M	B+	376	F	B
337	M	D	377	M	IC
338	F	C	378	F	C
339	M	B+	379	M	A
340	F	D	380	M	A
341	M	B+	381	M	B+
342	M	C	382	M	B
343	M	D+	383	F	D
344	M	B	384	F	C
345	M	D+	385	M	C+
346	M	D+	386	F	D+
347	M	D+	387	F	D
348	M	B	388	M	C+
349	F	D	389	M	E
350	M	D+	390	M	D+
351	F	B+	391	F	D+
352	M	D+	392	M	D
353	F	IC	393	M	D
354	M	B	394	F	D
355	F	D	395	F	D
356	F	C	396	M	B+
357	F	D	397	M	A
358	M	D+	398	M	B+
359	F	C	399	M	C+
360	F	B	400	F	C+

Source: Report on PCE, Akropong Akuapem (2018/2019 & 2019/2020) Academic Year for First Year.

Appendix B

Research Permit from Presbyterian College of Education, Akropong, Ghana



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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

Appendix C

Grading System in the Colleges of Education in Ghana

Grade	Range of 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 write exams or assignment	0

Source: Presbyterian College of Education Assessment Unit