Examining Attitudinal Traits and Geometry Achievement of the Pre-service Teachers

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Abstract: The performance of students in geometry has been consistently linked with attitude. Some attitudinal constructs (enjoyment, confidence and usefulness) and their link with pre – service teachers' achievement in geometry are investigated in this study. This quantitative study employed a questionnaire on the enjoyment, confidence, and usefulness of geometry together with a test on geometry, in order to take data from pre – service teachers. A systematic sampling of 225 pre – service mathematics teachers in second year made up the participants of this study. The results showed that confidence, enjoyment and usefulness were all positive and this indicated a positive attitude of pre – service teachers toward geometry. There was also a negative relationship between their attitude and their performance. However, multiple regression analysis indicated that Confidence was the highest predictor of achievement followed by enjoyment and usefulness.

Keywords: Attitude, Achievement, Pre-service mathematics teacher, Geometry, Confidence, Enjoyment and Usefulness

1. Introduction

Attitudinal traits have pertinent effects on students' learning of geometry. By rationale thought, performance, teaching and learning of geometry will be more effective if learners have a positive attitude towards geometry. A positive attitude definitely yields a positive result. Thus, students will obtain good outcomes in geometry if they have a positive attitude towards the subject and they will attain poor results if they portray a negative attitude. Studies have shown that, the poor performance of students have been consistently linked with attitude, although there exist several other influential factors (Abdullah & Zakaria, 2011). Factors like anxiety (sometimes referred to as fear), negative perception and myth of the difficulty of the subject usually affect its learning (Mogari, 2003). The broad nature of attitude construct cannot be entirely explored and this provides a strong basis for this study as Enjoyment, Confidence and Usefulness of geometry make up the specific attitudinal traits considering the pre – service teacher. Moreover, several studies on attitude in geometry have usually focused on students at the pre – tertiary levels. For instance, Abdullah and Zakaria (2011) studied attitude of form two students in Malaysia and their study considered Enjoyment as an attitudinal trait as well as Motivation and Valuation of geometry. Their study focuses on traits pertaining to students at the pre – tertiary level and there is no priority given to those at the tertiary level. Another study on attitude and achievement in geometry by Mogari (2003) also investigated enjoyment, motivation, liberty from the fear of geometry and perceived importance of geometry. Mogari (2003) combined these four (4) sub – constructs to make up attitude of grade ten students but the outcome of his study cannot be generalized for pre – service teachers who are prospective teachers of geometry.

Some studies indicate that there exists meaningful association between attitude and performance (Michelli, 2013; Schenkel, 2009). On the contrary, other previous researches also showed there is no relationship or the link between attitude and achievement is weak (Mohd, Mahmood & Ismail, 2011; Mogari 1994). A close look into studies in relation to geometry highly engineers this study to investigate Enjoyment, Confidence and Usefulness of geometry as each shows a varying relationship with geometry. Issues of the predictability of Enjoyment, Confidence and Usefulness are examined in relation to pre – service teachers' achievement in geometry. All in all, the present study sought to answer the following two research questions:

1. What is pre-service teachers' Enjoyment, Confidence and Usefulness of Geometry?
2. What relationship exists between pre-service teachers' attitude toward Geometry and their achievement?

2. Literature Review

2.1. Van Hiele Theory

Geometry covers a wide range of concepts and one of the most common theories that is used to assess students' geometric reasoning and understanding is the Van Hiele Theory (Armah, Cofie, & Okpoti, 2018). In this study, the reasoning of pre – service teachers is explained by their performance in geometry. Human geometric reasoning varies and it is sometimes not fully accurate because of distinct levels of comprehension and reasoning skills (Hourigan & Leavy, 2017). Pierre and Dina Van Hiele were Dutch scholars who designed

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this framework in order to help examine the different levels of geometric thinking that humans have. The model is designed in accordance with five (5) separate but sequential levels of geometric thinking. The five phases progress from levels which are very sequential and well classified based on the content and geometric competency expected of a learner (Hourigan & Leavy, 2017). The five levels have been grouped from level 0 to level IV. The first level is level 0; the second is Level I; the third is level II; the fourth is level III and the fifth is level IV. These levels are discussed below.

Level 0, which represents the first level is purposed to concentrate on visualization and recognition. The first level can also be classified as the visual level. At this level, learners evaluate geometric figures by how they see them. They are more interested in the shape and the visual representation of figures. They judge by what and how they see a geometric figure (Vojkuvkova, 2012). For instance, they recognize a rectangle by saying it looks like a wooden board. At this first level, learners are not abreast with geometric properties like length of a figure, the angle or size of angle, the diagonals or even the sides. They only judge based on the appearance of the geometric shape.

At the second level, that is Level I, the learner is able to describe geometric figures. Here they are able to identify the characteristics of geometric figures. This level is commonly called the descriptive level or the analysis level. At this level, learners are also capable of identifying relationships between shapes based on their properties (Bonyah & Larbi, 2021). For instance, they can identify that, rectangles and squares have their sides although they have different properties with regards to length. At this level, learners are able to distinguish based on the properties. They are able to classify three-sided plane shapes as triangles and four- sided planes shapes as quadrilaterals. They can also identify types of angles, types of triangles, types of quadrilaterals and many more classifications, description, analysis and relationships based on properties.

At the third level of Van Hiele's theory, that is level II, learners are expected to be capable of making deductions. This stage (that is level II) is also called the informal deductive level. Learners are expected to be able to order geometric figures. Although, they may have mastered classification objects, they are expected to be able to make correct ordering and inferences when it comes to the knowledge of geometrical shapes or figures. They (learners) are able to justify geometrical statements and they can make proper arguments regarding knowledge in Geometry. Thus, at this level, learners are able to justify why a Kite is not a rectangle, although they are both quadrilaterals and have two pairs of side being equal students at these levels are able to justify whether a square is a rectangle or not. Making informal deductions is very essential at the third level.

The level III is the fourth level, where learners are able to make formal deductions and establish knowledge base. Here they are able to prove theorems and give the basis of theorems. They tend to understand the need for axioms and they are able to prove theorems based on their knowledge of axioms. Their understanding of the need for axioms makes them capable of making premises that require deep reasoning (Hourigan & Leavy, 2017).

The last level to be considered is the level IV. It is also regarded as the Rigour stage. It is the highest level of Van Hiele's level of geometric reasoning and as such it encompasses the highest reasoning skills.

Comparing to the fourth level, this highest level is the stage where learners are able to apply axioms. Here they able to define various axioms and make constructive comparisons of the axioms. They can extensively analyze axioms and apply to proving theorems in Geometry. Learners at this level are not limited to only the Euclidean aspect of Geometry, but they are also able to understand non-Euclidean Geometry.

Halat (2008) suggests that, the fourth and the fifth levels of Van Hiele stages are normally needed at the higher levels, for example high schools, colleges or universities. The first, second and third levels are the knowledge base that can be directed at the elementary or primary schools. This means that pre – service teachers' knowledge can be examined with the geometric areas described by the Van Hiele's stages of geometrical reasoning.

2.2. Attitude towards Geometry

Attitude basically means the disposition to like something or to dislike it (Hannula, 2002). One's disposition is his or her feeling about a situation. Attitude towards Geometry can thus be seen as one's feeling about Geometry. The person's feeling or disposition about geometry can be positive, negative or neutral. According to Abdullah and Zakaria (2011), attitude towards a subject explains how one favors or disfavors the subject. This makes attitude a clear affective feature and measuring it can be directed towards specific attributes depending on the context to be used. Attitude is very composite in nature and it constitutes several constructs. These specific attributes within attitude as a whole can be the constructs used in a study. For instance, motivation in a subject can be a construct to be measured as an attitudinal construct. Some illustrative examples are given of self – confidence in Geometry, valuation attached to geometry as well as enjoyment in Geometry. Abdullah and Zakaria (2011) studied attitude by subdividing it into motivation, valuation and enjoyment in geometry. A study by Tapia and Marsh (2002) also considered factors like enjoyment, motivation, self – confidence and valuation.

Critical look at these studies in geometry and mathematics in general directed this study to select three attitudinal constructs, that is enjoyment, usefulness and confidence in Geometry. Enjoyment in learning Geometry can also be the happiness students find from the exposure they have in Geometry learning (Cavallo & Laubach, 2001). A current study by Segarra and Julia (2022) explained usefulness in Mathematics as an attitude that has to do with the value one regards in the subject. The value can be based on various reasons. Some learners may attach value to geometry because of its need in other subjects; others may value it because of its necessity to their future professions. Segarra and Julia (2022), in their study on Mathematics efficacy beliefs explained confidence as the capacity to do what is expected of an individual. A person's confidence has a link with anxiety. Someone who is very confident can be said to be less anxious (O'neal, 1988).

2.3. Attitude and Achievement in Geometry

In Africa, a study by Mogari (2003), investigated attitude towards Euclidean geometry and also the performance of students in Euclidean geometry. The researcher examined more of the affective aspects of attitude by selecting four variables: motivation, enjoyment, liberty from the fear geometry brings and importance perceived in learning geometry. The performance of these students in geometry concentrated on test items on solving problems in geometry and proofs. The outcome of the geometry test scores was low but the attitudinal scores were high and this indicates non alignment with studies that say high performance will surely indicate the existence of positive attitude (Karjanto, 2017).

A study of attitude toward Geometry by Dede (2012) also posited the fact that one's attitude change over time. He primarily sought to investigate whether attitudinal variables like usefulness, enjoyment and anxiety change as learners progressed from grade 8 through to grade 11. Further analysis of the data collected indicated that usefulness, as a factor in attitude toward geometry was increasing across grade levels, from Grade 8 to Grade 11 making it very predictable that as students progress to higher levels, they see geometry as very important and of great utility (Dede, 2012). The enjoyment aspect also had an increasing mean value through the grade levels, clearly indicating that students' attitude as to whether geometry was enjoyable was affirmative. The interesting finding in this study was that anxiety as an attitudinal variable did not consistently depict an increase or a decrease. For instance, at grade 10 and 11, the mean value showed a positive attitude for usefulness and enjoyment toward geometry, but the mean value for the anxiety was less showing a negative attitude.

3. Methods

3.1. Research Design

This study employed a quantitative approach in order to specifically examine the relationships between some influential attitudinal variables and achievement in geometry. The attitude as a construct of pre – service teachers consisted of three sub – constructs, that is enjoyment, usefulness and confidence in geometry. This study also considers the achievement of pre – service teachers in geometry as a dependent variable as the attitude serves as the independent variable.

3.2 Participants

Mathematics students who are being trained as teachers at Akenten Appiah – Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) were the main participants of this study. A systematic sampling approach was used to choose 225 mathematics students who are in the second year. These students have studied geometry throughout high school and have taken courses in geometry at the tertiary level. Some of them have been through colleges of education and are already teaching mathematics prior to their University admission. Hence the study classifies these participants as pre – service teachers although they double currently as students.

3.3 Data Collection Procedures

The Fennema-Sherman Attitude Scales (1976) and Geometry Attitude Scale as constructed by Utley (2007) served as a guide to develop a questionnaire which could measure the attitudes of pre-service teachers towards geometry. The Fennema-Shearman Attitude Scales (1976) looks at attitude toward mathematics with nine (9) sub – scales (Confidence, perceived usefulness, anxiety, effective motivation, teacher, success, mother, father as well as math as male domain scales). Also, the Geometry Attitude Scale (Utley, 2007) adopts three sub – scales (that is usefulness, effective motivation and confidence) from the Fennema-Shearman Attitude Scales. For this study, Confidence, Usefulness and Enjoyment are chosen but adopted to relate to Geometry, which is an aspect of mathematics. Attitude is broad but these three sub – scales are of major interest when the pre – service teacher is concerned. Thus the three (3) sub constructs making up the attitude were confidence in learning Geometry, enjoyment in Geometry and usefulness of Geometry. The instruments were piloted and the preliminary outcomes helped to design 26 items for all three sub constructs. There were 8 items for Confidence, 8 for Enjoyment and 10 items for Usefulness of Geometry.

Van Hiele's test items and the geometry contents of the Ghanaian curriculum were also adapted to measure the achievement of pre – service teachers in geometry. The test consisted of ten (10) items on geometry which covered areas on polygons, circles, equations in geometry and some proofs in geometry. With a well – designed scheme, the test was scored at an overall 30 marks however they were grouped into classes and graded to easily analyze and generate relationships with the pre – service teachers' attitude and also analyze the predictability of their confidence in learning Geometry, enjoyment in Geometry and usefulness of Geometry.

For this study, both descriptive and inferential statistics were used. Descriptive statistics like the mean and standard deviation aided in determining the confidence, enjoyment and usefulness of geometry as perceived by pre – service teachers. The overall attitude was determined by the use of the mean. The achievement of the pre – service teachers was also assessed and the minimum, maximum and mean scores were obtained. Further, the Pearson product moment correlation, an inferential statistical tool, was also used to determine the relationship between attitude and achievement, however, the multiple regression analysis was used to further determine the predictability of the attitudinal sub constructs (confidence, enjoyment and usefulness of geometry) in relation to the dependent variable (achievement).

3.4 Validity and Reliability Analysis

The questionnaire on attitude was designed in accordance with accepted questionnaire instruments, that is Fennema-Sherman Attitude Scales (1976) and Geometry Attitude Scale as constructed by Utley (2007). Three expert reviewers also went through both questionnaire and test instruments to modify and ensure that the instruments are appropriately deigned. The internal consistencies of the questionnaire were also determined and the Cronbach coefficient was 0.88 which indicated that the reliability of the instrument was appropriately met (Thanasegaran, 2009)

4. Findings

4.1. Pre-service Teachers' Attitude towards Geometry

The attitude of pre – service teachers was analyzed with help of a five – Likert scale that ranges from strongly disagree to strongly agree. Table 1 shows the results.

Table 1. Attitude towards Geometry

Attitude Scales	Mean	SD
Confidence	3.72	.67
Enjoyment	3.71	.67
Usefulness	3.64	.64
Overall Attitude	**3.69**	**.58**

Note: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

This part of the results considers the whole attitudinal variable and table 1 shows the scores based on the sub – constructs of attitude before finally indicating the score for the attitude. As indicated earlier, confidence (M = 3.72, SD = .67), enjoyment (M = 3.71, SD = .67) and usefulness (M = 3.64, SD = .64) were all positive and the overall attitude (M = 3.69, SD = .58) also showed positive attitude. This means pre – service teachers have a positive attitude toward geometry.

The achievement test on geometry was taken by the sample of 225 pre – service teachers and the scores were between the range of zero (0) and thirty (30). Table 2 and 3 depict the performance of the participants as indicated statistically.

Table 2. Geometry Achievement Test Scores

Score	Frequency	Percentage (%)
0 – 6	49	21.8
7 – 12	95	42.2
13 – 18	51	22.7
19 – 24	24	10.7
25 – 30	6	2.7
Total	**225**	**100**

From Table 2, 49 students had between the scores of 0 and 6 and that constituted 21.8% of the total participants. The highest number of students (95) had between the scores of 7 and 12 and that was a percentage of 42.2%. Also for the scores that range from 13 – 18 and 19 – 24, their frequencies were 51 and 24 respectively and they had corresponding percentages of 22.7% and 10.7 %. The smallest number from the table 2 was 6 and this corresponds to scores from 25 to 30. This clearly shows that the performance of pre – service teachers in the Geometry test was not good. Additionally, Table 3 depicts the descriptive analysis from the achievement test. The minimum score obtained was 0.

Table 3. Descriptive analysis of Achievement Test

	N	Min.	Max	Mean	Std. Dev.
Scores	225	0	25.0	10.98	5.98

This means some of the students could not give accurate answer to any of the geometry questions given in this study. The maximum score for the test was also 25. However, the mean score was 10.98 and when compared to the highest score that could be obtained, the difference is very high. The standard deviation of 5.98 shows that scores are highly spread about the mean.

4.2. The Relationship between Pre-Service Teachers' Attitude toward Geometry and Geometry Achievement

To find out the relationship between attitude and achievement of pre – service teachers, the Pearson correlation coefficient was found and the interpretation is given as shown in Table 4. A multiple regression analysis was also done to find out the predictability of enjoyment, confidence and usefulness in relation to achievement in geometry.

Table 4. Correlation between Pre-service Teachers' Attitude and Achievement

Statistics	Value
Pearson Correlation	$-.272^{**}$
Sig. (2 – tailed)	.000
N	225

Note: Correlation is significant at $p < 0.05$ *(2 – tailed)*

Table 4 shows the correlation results between pre – service teachers' attitude toward Geometry and their achievement in Geometry. The results show a negative relationship between their attitude and their performance ($r(225) = -.272$, $p = .000 < .05$). There exists a relationship but the relation is weak ($r = -.272$) since the absolute magnitude ($r = .272$) is less than .4 (Schober, 2018). The attitude and achievement results for this study does not move in the same direction as indicated by the negative correlation. This study found positive attitude as showed in Table 4, but performance in geometry is not entirely good hence the negative correlation.

A multiple regression analysis additionally shows the predictability of the attitudinal sub constructs in relation to the dependent variable (achievement) (see Table 5).

Table Hata! Belgede belirtilen stilde metne rastlanmadı.**5.** Multiple Regression analysis

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.875	.197		4.443	.000
Confidence	−3.005	.708	−.384	−4.247	.000
Enjoyment	.370	.732	.048	.506	.613
Usefulness	.122	.611	.016	.199	.842

Note: a. Predictors: (Constant), Confidence, Enjoyment and Usefulness; b. Dependent Variable: Achievement

Table 5 represents the regression analysis taking into consideration the dependent variable (achievement) and the sub constructs of attitude (Confidence, Enjoyment and Usefulness) making up the independent variables. The results reveal that Confidence predicts the achievement of students very highly but negatively ($b = -.384$, $p < .05$). The Enjoyment construct also predicts achievement as the second highest ($b = .048$, $p > .05$) and Usefulness is the least predictor of geometry achievement ($b = .016$, $p > 0.05$). Confidence is the highest predictor variable and also a significant predictor however Enjoyment and Usefulness also predict achievement but these factors are not significant.

5. Discussion

The study revealed from the findings that pre – service teachers have a positive attitude toward geometry. With an overall mean of 3.69, which indicated a response of agreement, the indications were that pre – service teachers had a positive attitude toward geometry. The findings are consistent with a study by Mogari (2003) which also considered students' attitude toward Euclidean Geometry and their achievement in the subject. Mogari (2003) investigated attitude but looked at sub – constructs: motivation, enjoyment, liberty from the fear geometry brings and importance perceived in learning geometry. For his study, Mogari (2003) considered the sub – constructs together but indicated that they all had high scores, that is they were all considered positive. The entire attitude of students towards geometry was positive based on his findings. Avcı et al. (2014) also examined attitude based on some variables and they were students of different institutions, levels, fields and gender. Their findings showed differences in attitude but most especially it showed that mathematics and science students had

a positive attitude than social studies class. This was based on the students' type of field of study. For the present study, the study was limited to mathematics students and the results show that there is agreement with the study by Avcı et al. (2014). Further studies by Aktas and Aktas (2012), which examined the attitude of students towards Geometry in the Ordu City of Turkey, found that students had middle level attitude which is in contrast to the current study. The middle level attitude of students in the Ordu state as discovered by Aktas and Aktas (2012) indicates neutrality to attitude as compared to the present study, showing that students' attitude was neither positive nor negative. The present study showed higher attitude of respondents indicating positive attitude.

Furthermore, there was a negatively weak relationship between pre – service teachers' attitude in geometry and their achievement. Initial analysis indicated a positive attitude in the subject however the correlation coefficient of -.272 and significant value of 0.000 is negative which signifies that although the respondents have a positive attitude but their performance in the subject is low. A mean score of 10.98 for a total score of 30 in the test indicated a poor performance of the pre-service teachers. In comparison to a study by Mogari (2003), students also had high attitudinal scores but their scores in Euclidean geometry test were low. In his study, Mogari (2003) indicated that the scope of the geometry test was areas that have been learnt by students in their previous grade level (that is grade 9). Similar to the present study, pre – service teachers in their second year have gone through a geometry course already but their performance could not match up with their positive attitude. Also, the findings of the present study showed that the relationship between attitude and achievement in Geometry was significant which is in line with the study by Mogari (2003).

A study by Dede (2012) also found out that as students progressed from one level to the other, their attitude towards geometry changes. Three variables were taken together as attitude (usefulness, enjoyment and anxiety); the usefulness construct and the Enjoyment construct showed increasingly positive attitude throughout the grade levels of students but in reverse the anxiety construct depicted decreasing level of attitude. The anxiety is similar to the confidence level of the present study and the findings of Dede (2012) is inconsistent with the present study when it comes to the aspect of confidence in learning Geometry. This is because the present study depicts that Confidence in learning geometry is the highest predictor but the other two (Enjoyment and usefulness) are less predictive of achievement in geometry.

There are studies that are dissimilar to the results of this study. For instance, a study by Samur (2015) found that there was a strong positive relationship between students' geometry attitude and their achievement in geometry. In his study, there was high geometry achievement of eighth grade students and they also had a high level of attitude. Pambudi (2022) also found a significant positive correlation between students' attitude and their achievement in learning geometry. Pambudi (2022) completely represented attitude, as motivation in his study but it comprised some items of enjoyment, confidence and usefulness as used in the current study. The discovery of this study also contradicted that Unlu, Avcu and Avcu (2010) as their study on attitude toward geometry showed positive results in relation to pre – service teachers' achievement in geometry.

6. Conclusion and Recommendations

It can be concluded from the findings of the study that pre – service teachers have a positive attitude towards Geometry. The relationship between their attitude and achievement in Geometry was also was negatively weak but showed significant association. Aside the relationship between the attitude and achievement, the finding showed that the Confidence, enjoyment and usefulness; as attitudinal sub constructs were predictors of achievement in geometry but confidence was the highest predictor whereas enjoyment and usefulness were less predictive. It is recommended that pre – service teachers should be well equipped to master the contents of Geometry in order to match up with their positive attitude. They should also be exposed to the usefulness of geometry and the interesting knowledge acquired by learning geometry.

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