UNIVERSITY OF EDUCATION, WINNEBA

GENDER DIFFERENCES IN PRE-SERVICE TEACHERS' VAN HIELE'S GEOMETRIC REASONING LEVELS AND THEIR ATTITUDE TOWARDS GEOMETRY

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DECLARATION

Student's Declaration

I, Anas Seidu Salifu, declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ………………………………….

Date: ……………………………………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of this Thesis was supervised in accordance with the guidelines for supervision of Thesis as laid down by the University of Education, Winneba.

Name of Supervisor: Prof. M. J. Nabie

Signature: ………………………………….

Date: ……………………………………….

DEDICATION

To my two children Rizkatu Tipagya and Hifza Maltiti and my wife Sawudatu for their love and encouragement that propelled me to pursue this postgraduate study.

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ABSTRACT

The purpose of the study was to investigate gender differences in pre-service teachers‟ Van Hiele‟s geometric reasoning levels and their attitude towards geometry under the following variables (usefulness of learning geometry, confidence in learning of geometry and enjoyment of learning geometry) of Northern Region Colleges of Education. Also, the purpose was to investigate whether there is relationship between Pre-Service Teachers (PSTs‟) Van Hiele‟s Geometry Test (VHGT) achievement scores and their attitude towards geometry. In pursuance of this purpose, three research questions and three research hypotheses were formulated to guide the study. A cross-sectional survey design was used for the study. A mixed method approach was also adopted to collect the data, specifically the concurrent design where the qualitative and quantitative data were collected together. The population was all level 200 PSTs of Northern Region and sample drawn from Evangelical Presbyterian (E. P.)- Bimbilla, Bagabaga and Tamale Colleges of Education. The total sample was 240 PSTs comprising 120 each of female and male. The sampling procedures were convenient, stratified and simple random. The instruments used were 25-item VHGT and 32 item closed ended questionnaire adapted from Utley and 3 opened ended questions designed by the researcher on PSTs attitude towards geometry. The results of the different data sources: VHGT and questionnaires were used to answer the research questions and the hypotheses. The main findings from the study are captured as follows in line with the research questions and hypotheses. The female PSTs VHGT reasoning levels were 7 (5.9%) for level 0, 21 (17.5%) for level 1, 67 (55.8%) for level 2 , 25 (20.8%) for level 3 , 0(0.0%) for levels 4 and 5 while that for the male PSTs were 5 (4.2%), 23 (19.2%), 21 (17.5%) ,66 (55.0%), 4(3.3%) and 1(0.8%) for levels 1, 2, 3, 4 and 5 respectively. From the t-test analysis there was significance difference between the female and the male PSTs with (t (238) = -3.987, p = 0.000 < 0.05) in favour of the male PSTs. The male PSTs achieved a a higher mean performance (M = 11.43 , SD = 2.27) better than the female with (M = 10.25, SD = 2.33). Both gender PSTs had very weak positive correlation between their attitude towards geometry and achievements in all the VHGT levels. Also, there was no statistically significant relationship between both gender attitude and achievements scores in all the VHGT levels. However, there was significant difference between female and male PSTs attitude toward geometry in favor of the male PSTs. The study recommended that tutors should use the VHGT to assess PSTs levels before any intervention measure in geometry and encourage tutors to adopt Van Hiele‟s phase based model for in teaching geometry to build PSTs confidence and interest.

CHAPTER ONE

INTRODUCTION

1.0 Overview

In this chapter, the background to the study, the problem statement, objectives of the study, research questions and research hypotheses are discussed. The chapter also presents the significance of the study, delimitation and concludes with organization of the study.

1.1 Background to the Study

The socio-economic and technological development of a nation depends mostly in advancement in science, technology and mathematics (Anne & Obinna, 2010; Atebe, 2008; & UNESCO, 2012). This is because Mathematics plays a pivotal role in science and technology advancement. Mathematics offers the laws, formula and the theories that enable the scientific and technological developments as buttressed by Musa (2006).

Countries all over the world place emphasis on the need for the delivery of good quality Science, Technology and Mathematics Education for their people. Indeed, for an applicant to gain admission into tertiary institutions like College of Education, he/she must have credit in Mathematics. It is in this regard that, the Ghana government with her educational collaborators like the Transforming Teacher Education and Learning (T-TEL) have drawn a new 4 year Bachelor of Education curriculum (2018) for all Colleges of Education (CoE) and the public universities responsible for training teachers. Transforming Teacher Education and Learning (T-TEL) is a four-year (2015-2018) Government of Ghana programme funded by UK aid. It was designed to transform the delivery of Pre-service Teacher education in

Ghana by improving the quality of teaching and learning through training support to all 46 public Colleges of Education in the country. The new programme has placed serious emphasis on gender issues because every College of Education was made to draft it own gender policy which is been followed strictly and monitored by T-TEL and National Council for Tertiary Education (NCTE). Also, in Ghana several interventions and programmes have been introduced in the educational sector by government and other stakeholders in the education notably T-TEL and other Non-Governmental Organizations like Ibis and Campaign for Female Education (CAMFED) to remove the gender gap in Mathematics, Science and Technology. For example; Science, Technology and Mathematics Education (STME) camp is a yearly programme aimed at supporting girls to gain practical exposures to various STEM related careers. It is also expected to increase girls interest in science and mathematics.

In the new 4-year B.Ed. curriculum, Pre-service teachers (PSTs) are supposed to be trained for effective delivery in one of the following levels; Lower Primary (Kindergarten to P3), Upper Primary (P4 to P6) and Junior High School (JHS1 to JHS3). In the new programme pre-service teachers (PSTs) are to also pick a major and a minor course as their specialized courses of study.

Mathematics is a compulsory subject of study from primary to Colleges of Education levels. The study of Mathematics by pre-service teachers is vital as it provides an avenue for developing scientific structure, thinking logical, drawing conclusions and solving real life problems. Geometry has useful links to many other fields of human endeavour. “The study of geometry contributes to helping students develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof' (Armah, Cofie, & Okpoti, 2017, p. 98). Also, Erdogan, Akkaya, and Celebi (2009) posited that the study of geometry has been acknowledged as a technique for students to major basic skills such as comparison, analysis, generalization and other cognitive skills that will help them gain better understanding of the world. The study of geometry offers many foundational skills of logic, deductive reasoning, analytical reasoning and problem solving (Armah, et al., 2017). According to Russell (2014) and Sunzuma, Masocha and Zezekwa (2013) geometry is also linked to many other areas in mathematics such as measurement, algebra, calculus and trigonometry and is used daily by architects, engineers, physicists, land surveyors and many more professionals as cited in Armah, Cofie, and Okpoti (2018). As a researcher I believe that the usefulness of learning mathematics helps in developing research skills, which every subject or course incorporates to investigate and solve problems. The study of geometry is very important as it has been recognised as a basic skill in mathematics (National Council of Teachers of Mathematics, 2000) and has many applications to topics in basic mathematics (Sherard, 1981). Hatfield, Edwards, Bitter and Morrow (2000) have stressed that geometric regions and shapes are essential for teaching and learning of fractions, decimals and percentages.

According to Usiskin (1982), geometry is vital for learning functions and calculus. For instance, the derivative of a function can be visualized as the slope of the tangent line to the graph of the function or the definite integral as the area under a curve (Usiskin, 1982). Van de Walle (2001) also reported that geometry is a footing for study in other fields such as science, engineering, architecture, geology and astronomy. Furthermore, arranging a living room, making frames, planning a garden, as well as in various aspects of construction work are real life application of geometry

(Hatfield et al., 2000; van de Walle, 2001). O'Daffer and Clemens (1992) also stated cultural and aesthetic values are derived from the study of geometry. In spite of the importance of geometry in real life, the performance of Ghanaian students in geometry is still disappointing as stressed in a number of reports in international assessment studies like Trends in International Mathematics and Science Study (TIMSS) in the years 2003 and 2007.

According to Akayuure, Asiedu-Addo, and Alebna (2016) in Ghana, the primary school geometry is treated as shapes and space and is roughly 17% of the major content area in the Mathematics teaching syllabus. Geometry in the primary school is treated as solid shapes, Shape and space, area and Length, measurement of length and area, finally area and Volume. In the Junior high school the topics are Shape and Space, Length and Area, Angles, Geometric Construction, Properties of Quadrilaterals, Area and Volume, Rigid Motion, Enlargement and Similarities, and Properties of Polygons. Teaching space and shape rationale is to give pupils early development of spatial visualization and mental rotation abilities and to enable them "organize and use spatial relationship in two or three dimensions, particularly in solving problems" (Ministry of Education, Science and Sports (MOESS), 2007, p .ii) and for progress in learning higher Mathematics.

Geometry topics in Ghana are taught as content and methods in the colleges of education in Ghana. The content of geometry is taught in the first year of the first semester under the course title Algebra and Geometry with the Course Code: FDC 112M. It is required that all mathematics and science students take FDC 112M. For the Science and maths students, FDC112M (content) is taught in the first year of the first semester while that for the general programme is taught in the second semester of the first year. The geometry component of FDC 112M for PSTS is presented in Table 1.

Table 1: Content of geometry in FDC112M

Unit	Topics	Sub-Topics	Suggested Duration
1	Lines and angles. Polygons	Parallel and perpendicular lines and transversals; sum of interior and exterior angles of polygons.	1 week
2	Geometric constructions and loci	Construction of triangles, quadrilaterals (using a pair of compasses and a ruler only). Construction of parallel and perpendicular lines, circumscribed and inscribed circles.	2 weeks
3	Mensuration	Surface areas and volumes of three-dimensional shapes.	1 week
4	Coordinate geometry and equation of a circle	Distance between two points, division of a line into a given ratio, midpoint of line segments, slopes (gradients) of lines, equation of a straight line – intercept form, slope-intercept form, general form. Parallel and perpendicular lines. Standard and general forms of equation of a circle e.g. $(x-a)^2+(y-b)^2=r^2$; $x^2+y^2+2gx+2fy+c=0$ Determining the centre and radius of a given circle.	2 weeks
5	Circle theorems	Circle theorems including tangents and their applications.	2 weeks

Source: Institute of Education (IOE) –UCC, (2014)

Table 1 is the geometry content topics for the science and mathematics students. The geometry topics has five (5) major units to be taught in eight weeks. All the topics have their respective duration to be taught with suggested week(s) to teach those topics. But tutors have the liberty to rearrange the topics for teaching. Table 1 also displays the sub-topics to be covered within the semester.

By the end of the geometry course, the student will be able to: (1) review and consolidate the concepts and skills related to Geometry, (2) discover relations involving shapes, perimeters, areas and volumes and use these to solve problems and finally (3) relate and apply mathematical knowledge to solve problems in Geometry, using appropriate procedures and tools like computers and calculators.(IOE-UCC, draft syllabus, 2014).

For the general programme PSTs geometry is taught in the first year of the second semester of the academic year. The duration and schedule period for teaching the geometry various units in the PSTs programme is presented in Table 2

Table 2: Content of geometry in FDC112

Unit	Topics	Sub-Topics	Suggested Duration
1	Lines and angles, Polygons.	Types of angles; Parallel lines, Perpendicular lines and transversals; Interior and exterior angles of polygons.	1 week
2	Geometrical construction including loci	Construction of angles, triangles quadrilaterals (using a pair of compasses and a ruler only) Construction of circumscribed and inscribed circles and loci.	2 weeks
	Circle theorems	Circle theorems including tangents and their applications.	1 week
3	2-Dimensional and 3-Dimensional shapes	Perimeter and areas of two-dimensional shapes, (including circles), surface areas and volumes of three-dimensional shapes.	2 weeks
4	Movement Geometry and Vectors	Vector representation: types of vectors (column vector $\binom{a}{b}$), row vector, $+ bj$; position vector; Magnitude of a vector; Addition and subtraction of vectors; Scalar multiplication of vectors; Translation reflection, enlargement and rotation and, line symmetry, rotational symmetry and order of rotational symmetry.	2 weeks
5	Co-ordinate Geometry	Distance between two points; midpoints of line segments; slopes (gradients) of lines, equation of a straight line.	2 weeks

Source: Institute of Education (IOE) –UCC, Draft Syllabus (2014)

Table 2 is the geometry content topics for the general programme students. The geometry topics have five (5) major units to be taught in ten weeks. All the topics have their respective duration to be taught with suggested week(s) to teach those topics. But tutors have the liberty to rearrange the topics for teaching. Table 2 also displays the sub-topics to be covered within the semester.

PSTs are taught mathematics methodology in the second year of the programme. In mathematics methodology, the geometry topics are classified under the following teaching measurements, geometric shapes, and constructions. The subtopics in teaching measurements are Length, time, money, capacity, mass, angles (using the protractor to draw and measure angles, sum of angles in a triangle and other polygons (interior & exterior), perimeter of polygons, circumference of a circle, areas of 2-D shapes, and volumes of (cubes, and cuboids, cylinders). The mathematics methods course is aimed at developing per-service teachers‟ with both sound mathematical and pedagogical content knowledge.

In any educational setting, the teacher is viewed as an expert who possesses specific and adequate content and pedagogical knowledge. Both the Ghana Education Service and Colleges of Education have played various roles in upgrading teachers technological pedagogical content knowledge base through subject based in-service training programme on challenging topics in mathematics including 2-D and 3D geometry concepts. For example, the Transforming Teacher Education and Learning (T-TEL) programme has instituted weekly professional development sessions in Colleges of Education to sharpened tutors skills on creative approaches, questioning, talk for learning, using games and using local materials as teaching learning materials in lesson delivery. All these are done to make learning of mathematics interesting and to promote pre-service teachers positive attitudes towards mathematics. But the appalling poor performance of pre-service teachers in geometry continue to be an apprehension to educational stakeholders.

Asemani, Asiedu–Addo, and Oppong (2017) have indicated that researchers and teachers around the globe have presented a number of factors to explain why learning of geometry is difficult. The perceived factors are: (i) Language of geometry (ii) Visualization abilities (iii) Ineffective instructions (iv) Poor reasoning skills (Asemani, et al., 2017). Several authors (Anamuah-Mensah & Mereku, 2005; Armah, et al., 2017; Baffoe & Mereku, 2010) raised apprehensions about the levels of students‟ geometric thinking in Ghanaian schools, most especially at the basic and senior high schools. Over the past four decades several research investigations around the globe have sought to examine differences in males and females mathematics learning and attitude toward geometry, (Else-Quest, Hyde, & Linn, 2010). For instance, Anamuah-Mensah and Mereku (2005) and Anamuah-Mensah, Mereku, and Asabere-Ameyaw, (2008), reported that Ghanaian Junior high school (JHS) students' performance in the geometry was abysmally low with mean score far below the international average in the Trends in International Mathematics and Science Study (TIMSS). These reports also indicated that Grade 8 pupils‟ from Ghanaian junior high pupils performances in geometry were among the lowest in five domains the test covered and the countries that participated in TIMSS studies in 2003, 2007 and 2011 (Gunhan, 2014; Mullis, Martin, & Foy, 2008). The TIMSS studies in 2003, 2007 and 2011 reports further revealed that with such students‟ abysmal performance in the subject, female students have had lower achievement as compared to their male counterparts.

In the Senior High School level gender differences existed between 2012 and 2013 academic years. Table 3 shows the gender of candidates presented in Ghana for the West African School Certificate Examination. Table 1.3 captured the total number of candidates and percentages by gender, pass (A1-C6) by gender, pass (D7-E8) by gender, and fail (F9) by gender.

Table 3: Performance of Senior High School candidates by gender from 2012 -2013

Year	Total candidates presented	Total presented female %	Total pass female % (A1-C6)	Total pass female % (D7-E8)	Total fail female % (F9)	Total presented male %	Total presented male % (A1-C6)	Total pass male % (D7-E8)	Total fail male % (F9)
2012	173,499	78,880 (45.46)	34,815 (20.0%)	26,850 (15.5%)	16924 (9.8%)	94616 (54.53)	51862 (29.9%)	27,325 (15.7%)	15,008 (8.6%)
2013	402,794	185,686 (46.09%)	61,350 (15.20%)	66,636 (16.5%)	57,700 (14.3%)	217,108 (53.90%)	87,217 (21.6%)	74,421 (18.4%)	55,470 (13.7%).

Source: WAEC, 2012 & 2013 - Ghana (available data).

Also, Asemani et al. (2017) found that the maximum Van Hiele"s level reached by a Ghanaian student completing Senior High School is level 3 (Ordering). This performance level is far below other students in other parts of the world that reached level 4 (Deduction) in geometry. In another study, Armah et al. (2017) expressed disappointment on PSTs geometric reasoning levels. Their study revealed that 75.33% of PSTs" van Hiele Levels were below Level 3 (Order) which is alarming. They argued that for PSTs to successfully teach geometry at the basic level such PSTs should be at Level 3 (Order) or above. Also, Baffoe and Mereku (2010) lamented that over 90% of Ghanaian JHS 3 students Van Hiele level of understanding geometry is lower than that of their colleagues in other countries.

Fletcher and Anderson (2012) study also found that senior high students were unable to answer problems demanding spatial visualization and geometric reasoning in relation to circle theorems, mensuration and other 3 dimensional problems in core mathematics. The West African Examination Council (WAEC) Chief Examiner"s annual reports for the West African Senior School Certificate Examination (WASSCE) from 2008 to 2011 observed that candidates were weak in 2 and 3-dimensional geometrical problems.

Table 4 presents the summary of PSTs performance in the geometry and trigonometry from 2007-2017. It shows the number of PSTs presented every year, the number that pass and the number that failed with respective percentages.

Table 4: Statistics of students' performance in geometry and trigonometry (2007-2017)

Year	Total Pre-service teachers presented	Number and Percentage failed	Number and Percentage Passed
2007	9168	5,207 (56.8%)	3,961 (43.2%)
2009	11492	3,654 (31.8%)	7,838 (68.2%)
2013	7449	924 (12.4%)	6,525 (87.6%)
2015	10348	2,980 (22.8%)	7,367 (77.2%)
2017	13513	417 (3.1%)	13096 (96.9%)

Source: Institute of Education –UCC, Professional board semester results analysis report for geometry for 2007,2009,2013,2015, and 2017 (available data).

Chief examiners annual reports for second-semester examinations on geometry in 2011 and 2012 indicate that; (i) pre-service teachers" solutions to a majority of 2D and 3D questions were poorly tackled. (ii) Pre-service teachers could not solve questions involving concepts of interior and exterior angles of polygons and their properties (Institute of Education, UCC-Ghana, Chief Examiner"s Report on the 2011 & 2012.

Gender is a vital factor in mathematics teaching and learning because many educational stakeholders are interested in it for planning and making forecast on education for the future. Studies (Doris, O"neill, & Sweetman, 2013; Kim & Law, 2012) indicate that there is growing interest around the world on studies on gender differences in mathematics performance. Asante (2010) indicated that at the elementary stages gender differences in Mathematics performance are not obviously clear but from the High school stages, female students start to lack behind their male counterparts. This can be simply put that gender difference in mathematics is also connected to the grade level. Exploring gender differences in achievement of geometry at Colleges of Education is worthy investigating, since there is no gender differences in achievement at basic level. Hence it will be very motivating to find out gender differences in geometry among the pre-service teachers‟ in Northern Region Colleges of Education. Mathematics achievement based on gender is not conclusive because there are so many other factors that accounts for Mathematics achievement, such as poor attitude and lack of interest by students.

Issahaq (2018) opined that weak foundation in mathematics in addition to negative perceptions and attitudes of Pre-Service Teachers towards mathematics primarily accounted for the gender differences in mathematics achievement among the PSTs of Evangelical Presbyterian (E. P.) College of Education- Bimbilla. His study found gender differences in favor of the male PST. Gavor (2014) research indicated that only 27.4% of females obtained the pass grades of A1 to E8 as compared to 70.5 % of their male counterparts in West African Examination Council (WAEC) in elective mathematics for senior high students when the total number of candidates was 59,400. However, in the core mathematics the males and females pass rates were 35.6% and 35.5% respectively. In 2013, the males still did better than their females‟ counterparts in Core Mathematics. The pass rates were 40.0% and 31.7% for male and female respectively. Also, in the same year the pass rate for Elective Mathematics for males and females were 54.3% and 23.1% respectively (WAEC, 2013).

Salifu‟s (2018) findings indicated that there was no significant difference in all the VHGT levels between the male and female PSTs. However, the male PSTs performed slightly better than their female counterparts in all the levels except only in level 4 which favoured the female PST. Also, in Arhin and Offoe (2015), they found that there were no gender differences among the male and female students in problem-solving abilities. Arhin and Offoe in their study concluded that there was no gender difference among the males and females students in problem-solving abilities. Female in the mixed-sex schools performed better than their male counterparts even though there was no statistically significant difference (Kwame, McCarthy, McCarthy & Gyan, 2015). In the Brong-Ahafo Region of Ghana, Tetteh, Wilmot and Ashong (2018) study indicated gender difference in favor of the female students.

Utley (2004) defined attitude towards geometry as a set of beliefs focusing on geometry that predisposed a person to respond in a certain way. The word attitude refers to a favourable or unfavourable feeling, the valuation of the positive or negative feeling when confronted with a particular object. In a study by Kyei, Apam, and Nokoe **(**2011), analyses indicated that male performed better than their female counterparts in mathematics. Their study also indicated that girls‟ lack of self-confidence in working mathematics problems in the Upper East Region of Ghana. According to Nyala (2008) there was no gender difference in students‟ attitude towards mathematics at Junior High School level.

Attitude and mathematics achievement have been extensively researched into by several researchers (Fraser & Kahle, 2007; Mato & De la Torre, 2010; Nicolaidou & Philippou, 2003) and they have either concluded with positive or negative correlation. So it will be significant to also find out whether this study with the PSTs would give a positive or negative correlation between PSTs achievement and attitude in geometry.

1.2 Statement of the Problem

The perception among Ghanaians is that females are inferior to their male counterparts in mathematics achievements and attitude towards the subject, yet these differences do not exist in the classroom when teachers are teaching both sexes. Tutors at the E.P College of Education, Bimbilla have made numerous efforts to teaching geometry to pre-service teachers for understanding with the view to increase their performance in their examinations (internal and external). However, the semester by semester analysis of candidates results from the Institute of Education, UCC have always indicated that PSTs are not performing well in geometry as expected.

The consistent poor performance is disturbing and has severe implication for geometry teaching as students‟ progress to higher areas of mathematics such as engineering math that entail strong geometric reasoning (Akayuure et al., 2016). The abysmal and consistent poor performance of PSTs in geometry has been an apprehension to College Mathematics Tutors, parents, and government. The chief examiners reports on geometry from the Institute of Education, professional board report UCC – Ghana, (see Table 1.4) has revealed that the poor performance is consistent.

Several researchers (Alex & Mammen, 2016; Armah, et al., 2017, 2018; Vojkuvkova, 2012; Yegambaram & Naidoo, 2009) proposed the adoption of Van Hiele theoretical model for teaching geometry as it has the potential to improve pre service teachers achievements in geometry at all levels of the educational ladder. Nevertheless, there is limited literature in using the Van Hiele model of teaching geometry in Ghana to investigate PSTs levels. Previous studies in Ghana indicated the lack of studies (gaps) using the van Hiele model to identify gender differences of students reasoning levels, their attitude towards geometry and correlation of PSTs VHGT achievements and attitude. Therefore, this present study sort to examine gender differences in pre-service teachers‟ Van Hiele‟s geometric reasoning levels and their attitude towards geometry as well as the correlation of PSTs achievements and their attitude towards geometry in Northern Region Colleges of Education.

1.3 Purpose of the Study

The purpose of the study was to investigate gender differences in pre-service teachers‟ Van Hiele‟s geometric reasoning levels and their attitude towards geometry in Norther Region. It was also to investigate whether there is relationship between PSTs‟ VHGT achievement scores and their attitude towards geometry. The focus is to understand whether male and female PSTs actually possess the geometric content knowledge and attitude for teaching Junior High Schools geometry.

1.4 Objectives of the Study

The study aimed to achieve the following objectives:

1. to examine PSTs‟ in Northern RegionColleges of Education geometric reasoning levels by gender.
2. to explore PSTs‟ in Colleges of Education in Northern Region attitudes towards geometry by gender.
3. to determine whether there is any relationship between PSTs‟ in Colleges of Education in Northern Region VHGT achievement scores and their attitude towards geometry.

1.5 Research Questions

In pursuance of the stated purpose, the following research questions were formulated to guide the study:

1. What are the geometric reasoning levels of PSTs‟ in Colleges of Educationin Northern Region by gender?
2. What are PSTs‟ in Northern Region attitudes towards geometry by gender?
3. What is the relationship between PSTs‟ in Northern Region achievement score and attitude towards geometry by gender ?

1.6 Research Hypotheses

The following hypotheses were formulated to correspond with the research questions.

1. There is no significant difference between female and male PSTs‟ VHGT achievement scores.
2. There is no significant difference between female and male PSTs attitude towards geometry.
3. There is no relationship between PSTs‟ VHGT achievement scores and their attitude towards geometry.

1.7 Significance of the Study

This study would provide useful information about what emphasis mathematics policy makers at the Colleges of Education would place on students‟ attitude towards geometry to enhance effective teaching and learning of geometry at the Colleges of Education (CoEs). This study will also provide information to show whether there is a significant difference in achievement in geometry among female and male PSTs, to help confirm or deny the impression that mathematics is the preserve of male students.

In addition, it would serve as a baseline study for policy makers in mathematics education to carry out other research work in a similar area and contribute to clarifying the confusion and gap in understanding gender differences in students' attitude and academic achievement.

The study would enable mathematics teachers at the Colleges of Education (CoEs) level to be informed of the effect of PSTs attitude and achievement in geometry and design appropriate methodologies to enhance achievement in geometry. This will enable teachers to implement a teaching and assessment strategy that is not gender biased. Also, to inform mathematics tutors and PSTs to consider gender issues seriously when teaching geometry or mathematics. The study would help Pre-service teachers to understand the importance of attitude towards geometry. This will encourage them to develop positive attitude towards geometry to enhance higher achievement.

1.8 Delimitation of the Study

In the Colleges of Education (CoEs), there are so many Geometry topics including two and three dimensional figures as captured in the background. However, for the purpose of this study, importance was only given to two dimensional figures instead of three dimensional figures. The selection of this area in geometry was as a result of the constant difficulties encountered by PSTs as revealed by the chief examiners reports as discussed earlier in the background and problem statement.

Also, in terms of content, this study focused on differences in male and female PSTs reasoning levels and differences in gender attitude towards geometry on these specific constructs (usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry) and not other constructs. Other geometry teaching models exist but the Van Hiele‟s model was used to assign the geometric reasoning levels of the PSTs. Even though PSTs find other areas of geometry difficult, time within which to complete this study was limited hence those other areas of geometry were not covered.

It would have been more appropriate to cover the entire Northern Region Colleges but due to the limited schedule time plan to submit this thesis. The research was restricted to only 3 Colleges, two in Tamale and one in Bimbilla.

1.9 The Organizational plan of the Study

This study is organized into five main chapters. In chapter One, the researcher discussed the background to the study, the problem that gave rise to the study, purpose of the study, objectives of the study and the research questions that guided the study. The rest are research hypotheses, significance of the study, and delimitation of the study. Chapter Two also focused on the relevant literature review based on the research questions and theoretical framework. It included discussions on the Van Hiele Theory, characteristics of the levels, phase based of learning, studies on Van Hiele theory in Ghana, gender difference in mathematics, students" attitude towards geometry and finally relationship of students attitude and mathematics achievement. Chapter Three entails the methodology used in the research process. It included discussions on research design, population, sample, instruments, reliability and validity of the instruments, pilot, data collection procedure, data analysis plan, ethical consideration and it ended with limitations of the study. Data collected from PSTs VHGT and attitude questionnaire were analyzed and presented in chapter four. The results were used to answer the three (3) research questions and three (3) hypotheses. Chapter five included the summary of the study and major findings made were presented followed by implication of the study and conclusion. Recommendations were also made including areas for further study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

The overarching purpose of this current study is to investigate gender differences in pre-service teachers"Van Hiele"s geometric reasoning levels and their attitude towards geometry of Northern Region Colleges of Education. Also, to investigate whether there is relationship between PSTs" geometric reasoning levels and their attitude towards geometry. The researcher essentially wants to figure out whether the PSTs actually possess the needed content knowledge to be able to teach their prospective junior high schools students. Since they are specifically trained to handle all Mathematics topics. In pursuance of this purpose, three research questions and three hypothesis were formulated to guide the study. To understand the purpose and answer these research questions and hypotheses fully, two (2) instruments were used to gather the necessary data from the PSTs. These were administration of 32 items attitude questionnaire and the 25 VHGT items. This chapter reviews the areas of literature pertinent to my research as follows: discussions on the history of Van Hiele Theory, characteristics of the levels, phase based of learning, studies on Van Hiele theory in Ghana and outside Ghana, gender difference in mathematics, students" attitude towards geometry and finally students" attitude and achievements.

2.1 The van Hiele Theory: A Historical Perspective

Many students have experience difficulties, and fallen far behind their colleagues in geometry and which has motivated several teachers to try new methods of teaching geometry in an attempt to correct the disparity. However, these new methods yielded very little success in geometry. Due to the frustrations encountered in teaching geometry in the 1950s, two Dutch Mathematics educators, Pierre van Hiele and Dina van Hiele-Geldof, investigated possible reasons that could have created such problems in teachers‟ classrooms. The couple and their students experienced difficulty during geometry teaching and learning. The emergence of the van Hiele theory of geometric thought came from the separate doctoral works of Dina van Hiele-Geldof and Pierre van Hiele, at the University of Utrecht, Netherlands in 1957 which were completed simultaneously (Armah et al., 2018; Salifu, 2018; Usiskin, 1982).

In their research, Pierre and Dina took different angles, Dina‟s dissertation looked at teaching experiment. In that regard she was more concerned and narrowed her work to ordering of geometry content and learning activities of students. Dina therefore moved to describe from a teaching viewpoint how to help children make progress with the Levels, and described five teaching phases within each level. Pierre‟s dissertation primarily focused on explaining why students experienced difficulties in geometry instruction, hence it was explanatory and descriptive. According to De Villiers (2004), Pierre was responsible for coming up with the model and describing these Levels in more details. Pierre clarified, amended, and advanced the theory because Dina died shortly after finishing her dissertation (De Villiers , 2004).

The couple works were very unhurried in gaining international attention. Between, 1958-1959, Pierre wrote three papers (two in English, one in Dutch but translated into French) about the theory but it attracted little attention in the West, but were used in curriculum development by the Soviet academician Pyshkalo in 1968 (Haviger & Vojkůvková, 2015). Later in the 1970s, a North American, Izaak Wirszup, began to write and speak about the model. At about the same time, Hans Freudenthal, the van Hieles‟ professor and mentor from the University of Utrecht, called attention to their works in his “massive” book, Mathematics as an Educational Taskin in 1973. Through Freudenthal and the Soviets, the work of the van Hieles came to the attention of Wirszup, who was the first to speak about the van Hiele theory on this side of the Atlantic in 1974 and later published his speech in 1976 (Crowley, 1987; Uziskin, 1982).

The van Hiele theory has now gained a lot of international attention. One of the major research works using the van Hiele framework was by Usiskin (1982) at the University of Chicago in the United States of America (USA). As opined by (Senk,1985; Usiskin, 1982), Americans also carried out several studies which influence National Council of Teachers of Mathematics .(NCTM) Standards and Common Core State Standards in the 1970s. Usiskin developed a test to measure learners‟ van Hiele Levels of reasoning. Based on Usiskin‟s work, the van Hiele theory has become the most influential factor in the American geometry curriculum (Van de Walle, 2001). There has since been an increased interest in the van Hieles‟ contributions as a significant amount of research in school geometry has focused on the van Hiele Levels of thinking. Consequently, several researchers have applied the theory to improve geometry instruction (Alex & Mammen 2012; Breyfogle & Lynch, 2010; Dindyal, 2007; Siew, Chong & Abdullah, 2013; Yazdani, 2007). It is indeed the wide and diverse use of the van Hiele theory that legitimizes it as a good yardstick with which to survey the geometry terrain of this study.

2.2 Theoretical Framework

2.2.1 Van Hiele Theory Levels

According to Van Hiele (1986), his distinguished five sequential levels of geometric thought depends on learners ability and previous geometry experiences. He also stressed that these experiences are not just gained in a classroom but consist of all the experiences that a child has been exposed to since birth. The presence of levels of reasoning is supported by other studies (Burger & Shaughnessy, 1986; Fuys, Geddes, & Tischler, 1988; Mayberry, 1983; Usiskin, 1982). Again, Usiskin (1982) concluded that the Van Hiele levels are a good predictor of the geometric performance of learners after the Chicago study group research project in the USA.

However, Frykholm (1994) also indicated the converse, that general mathematical performance is a predictor of Van Hiele levels. The levels were originally numbered by the Van Hieles from level 0 to level 4. This numbering system was still used by some of the seminal authors including Burger and Shaughnessy (1986), Fuys et al. (1988), Hoffer (1981), and Mayberry (1983). However, Usiskin (1982) and Pegg (1992) started numbering the levels from 1 to 5 instead, in order to allow for the pre-recognition level to be called level 0. This modification permits a sixth level named pre-recognition for students who will not achieve van Hiele level 1, (Mason, 1998). The five sequentially and hierarchical separate levels by Van Hiele (1986), are as follows (1) Visual, (2) Analysis, (3) Order, (4) Deduction, and (5) Rigor (Alex & Mammen, 2016; Usiskin, 1982) in ascending order of difficulty. Van Hiele wanted to know why students experienced difficulty in learning geometry and how he could remedy those difficulties. The solution van Hiele found for his students" frustrations was the theory of different levels of thinking. In Table 5, the Van Hiele levels from level 1 to 5 as used in this study is explained.

Table 5: The Van Hiele Levels of geometric thought.

Level	Name of level	Thinking Process	Explanation of Process
1	Visualization (Recognition)	Shapes and what they like	Sort and classify shapes e.g squares based on their appearance. Properties are not recognized.
2	Analysis (Descriptive)	Properties of shapes	Recognize the properties of the shapes but the properties are independent of one another.
3	Informal Deduction (Order)	Classes of shapes rather than individual shapes	Develop relationship between properties. Can see hierarchy of properties and shapes. Shapes go together because of the properties.
4	Deduction	Relationship among properties of geometric objects	Can work with abstract statements about geometric properties and make conclusions based more on logic than intuition. Proof can be done.
5	Rigor	Deductive axiomatic systems for geometry	An interest in the axiomatic systems themselves and not just the deductions within a system. Non-Euclidean geometry can also be applied.

Source: (Pegg, 1992; Van De Walle, 2004) cited by Steyn (2016, p.12)

Apart from the Van Hiele‟s levels, the Van Hiele‟s also proposed phases of learning for a learner to progress from one level to the next, together with the actions of the teacher and learners in each phase. The phases are Information (Inquiry), Guided (Directed) Orientation, Explicitation Free, Orientation and Integration. The properties of the levels were added to the theory to further describe the levels of geometric thought. These properties are Fixed Sequence/Hierarchy, Linguistic Character, Adjacency Advancement/Ascendancy and Mismatch.

2.3 Critique of the Van Hiele Theory Model

Usiskin (1982) advanced that the Van Hiele theory is "elegant, comprehensive and has a wide applicability" (p.6). The most important points of the critique and their propose solutions offered by the seminal authors are discussed below.

The First and foremost critique is that the theory does not describe the process within the levels sufficiently (Pegg, 1997; Clements, 2003). So, one of the study intentions by Fuys et al. (1988) was to set up more comprehensive descriptions of each level.

The second critique that is levelled against the van Hiele theory is discrete nature of the levels. Students do not progress from one level to the next in jumps but rather in small steps resulting in a more continuous progress (Battista, 2007). Also, Pusey, (2003) stressed that discontinuity between the levels is emphasised by the number of students who seem to fit in between levels. Clements and Battista (1992) and Mayberry (1983) in their studies also claimed that learners seem to be at different levels for different concepts or tend to fluctuate between the levels thus prompting the question, whether students can be assigned on a certain level. So with this argument, Battista (2007), Burger and Shaughnessy (1986), and Crowley (1987) and have therefore opined that a specific level cannot be assigned to a learner. To find solution to this concern Pegg (1997) study expanded levels 2 and 3 by merging the Van Hiele Theory with the Structure of the Observed Learning Outcomes (SOLO) taxonomy of Biggs and Collins (1982). Battista's (2007) solution to the second critique was adding sub-levels through elaboration on the levels. Also, Gutiérrez, Jaime, and Fortuny (1991) suggestion was by ascribing degrees of acquisition in a specific level.

A third critique is about pre- visualization level or level 0. The pre- visualization level is the level for learners who do not meet the criteria for the first level. The van Hiele theory does not make room for this level. This is supported by Usiskin (1982), Senk (1989) and Pegg and Davey (1989) researches that found that some students did not meet the criteria of the first level. Further studies by Clements (2003) revealed that the theory was not accurate in describing the thinking of very young learner. So Clements (2003) in that study changed the original numbering of the level from 0 to 4 to level 1 to 5 and a pre-recognition level or level 0 was added before level 1.

The fourth critique is about the methods of assessment of the levels. According to Battista (2007), he acknowledged that although researchers (Burger and Shaughnessy, 1986 and Crowley 1987) have gained a lot of knowledge about students thinking in geometry, it is still very challenging to assess the cognitive processes.

A fifth critique is against level 5 or the rigor level in the levels. Usiskin (1982) opined that this level could not be tested, hence does not exist. This suggestion was also later accepted by Van Hiele (1986) as part of his later work. Van Putten (2008), therefore stated that many scholars do not include this level in their assessments. Notwithstanding the criticisms of the Van Hiele theory, many studies such as Armah, et al., (2018), Burger and Shaughnessy (1986), Crowley (1987), Fuys et al. (1988), Hoffer (1981), Pegg and Davey (1989), Salifu (2018), Senk (1989), Steyn (2016), Usiskin (1982), Vojkurkova (2012) worldwide still use the theory in their studies and teaching.

2.4 Studies on Van Hiele theory

This review of research concentrates on more recent studies that have relevance to this study. Vojkurkova (2012) study aim was to use the Van Hiele theories to develop the students" ability in the concept of geometric congruency in triangles. Van Hiele theories should be transferred to other areas of mathematics such as algebra, functions, analysis, and calculus Dindyal (2007) study was interested in how learners think in geometry given its prominence in the school mathematics curriculum. The study focused on the prerequisite for an inclusive framework for learners" thinking in school geometry. At the end of his study, he advanced concerns about geometric thinking and the need to conceptualise geometric thinking within a broad framework. Dindyal (2007) recommended that the progression of a learner from one level to the next depends on the quality of experience that learner is exposed to, even though, his study did not emphasis on levels of geometric thinking.

In a study in China, Ding and Jones (2007) analysis indicated that though the first three levels of the van Hiele instruction phases were found in the country"s lessons, the teaching method of the guided orientation was not precisely the same as acknowledged by van Hiele model. The subjects were grade 8 learners in Shanghai. They used the van Hiele theory to evaluate the teaching lessons of geometrical proof. The aim of Chew and Lim (2013) study was to improve primary pupils' geometric thinking through phase-based instruction using the Geometer's Sketchpad (GSP) based on the van Hiele"s theory of geometric thinking. The purpose of their study was to enhance primary school pupils' geometric thinking on equilateral triangle, square, regular pentagon, and regular hexagon before and after a phase-based instruction using Geometer's Sketchpad (GSP). The other purpose was to find out whether there was any significant difference in the pupils' van Hiele levels of geometric thinking after the intervention. The research design used was exploratory case. The sample used for the study was 26 mixed-ability Year Four pupils from a primary school in Selangor. The van Hiele level test was administered to the pupils before and after the intervention to assess their van Hiele levels of geometric thinking about regular polygons. Chew and Lim (2013) reported that before the intervention pupils were predominantly at Level 0 (Pre-recognition) for regular pentagon and regular hexagon but at Level 1 (Recognition) for equilateral triangle and square. However, the post-test results revealed that the pupils' van Hiele levels after the intervention were predominantly at Level 2 (Analysis) for all the regular polygons. Also, the results of the Wilcoxon test recorded that there was a significant difference in the pupils' van Hiele levels of geometric thinking for all the regular polygons after phase-based instruction. Chew and Lim (2013) concluded that median van Hiele level in the post-test was higher than the median van Hiele level in the pre-test for all the regular polygons, indicating that the intervention had significantly enhanced the pupils' geometric thinking about the regular polygons.

In Malaysia, Abdullah and Zakaria (2013) used a quasi-experimental design for a six weeks duration involving 94 subjects in their study. Both the the control group and the treatment group were made up of 47 students each. The researchers used Van Hiele‟s phase-based learning to improve students‟‟ level of geometric thinking. The treatment and the control groups learned Form Two‟s Transformation topic through the Van Hiele‟s phases of learning using the GSP and traditional methods respectively. Prior to the study, students from both groups were given Van Hiele‟s Geometry Test (VHGT) to classify their preliminary levels of geometric thinking. The duration of the study lasted 6 weeks. At the end of the study, the students in both groups were given the VHGT for the second time to analyse and determine their final levels of geometric thinking. Wilcoxont-test of repeated measurement was used for the data analysis. The results found that the students in both groups showed increment in their post-VHGT as compared to the pre-VHGT. The analysis revealed that there was a statistically significant difference between the final levels of geometrical thinking between the control and the treatment groups.

The study carried out by Abu and Abidin (2013) indicated that majority of the secondary school students had shown an improvement in their geometric thinking level. Their study sought to improve the levels of geometric thinking of the subject using a geometry learning video called Pembelajavan geometry, and was based on the Van Hiele theory. The video was watched by 150 secondary school students on various Van Hiele levels. The findings of this study revealed that 90 were on level 0, 60 were on level 1, and 30 were on level 2.

Van Putten (2008) carried out a study which examined how geometrical concepts and knowledge were taught to a group of pre-service teachers, using the Van Hiele theory levels of teaching as the theoretical framework. The study revealed that most of the pre-service teachers were taught geometry with rote learning methods, using textbooks to present theorems and proof. From the study van Putten (2008) found that most of the proof exercises were obvious and were not challenging enough to force students to think while solving them. The study revealed that the participants had failed to recall geometric concepts they learnt instantly after and were not able to apply the concepts learnt in other related circumstances.

In a recent study Decano (2017) evaluated the cognitive development levels of college students and their achievement in Geometry using Piaget‟s Test of Logical Operations and Van Hiele‟s Levels of thinking. Decano (2017) used quantitative approach in his research with 105 respondents in which 71 fit the Van Hiele modified case/criterion "3 out of 5" correct answers. His study revealed that greater number of the college students were identified as concrete operational thinkers using Piaget‟s theory of concrete and formal operations who possessed the levels of classification, seriation and transitivity. Most of the students were classified as holistic thinkers by Van Hiele‟s levels of thinking. The study reported that students whose ages were from 20 years and above were performing better in Geometry as compared to the other age brackets. It also came to light that male students were performing better than female students. For the cognitive development levels using Piaget‟s theory on concrete and formal operations, Decano (2017) study revealed that there is a significant difference when grouped according to age and year levels. However, the research found a non-significant difference when grouped according to sex. The study concluded that there was a significant positive relationship between Van Hiele‟s levels of thinking, Piaget‟s theory of concrete and formal operations and Geometry achievement test. Van Hiele‟s levels of deductive and rigorous thinking and Piaget‟s levels of transitivity, proportionality and correlation are significant predictors in the achievement of students in Geometry. This suggests further that to be successful in learning Geometry and mathematics in general, a college student must reach Van Hiele‟ level 3 which is deductive thinking and Piaget‟s level 3 transitivity.

In another study, Tamer (2013) used a quasi-experimental pre-/post-test control group design. The study investigated the impact of presenting geometric concepts to participants by blending the Van Hiele instructional model and the use of Geogebra. Tamer‟s (2013) study revealed that the grade 11 learners in the experimental group were able to create their own geometric shapes and try different things with different shapes. Tamer also posited that the subjects participated actively in the teaching and learning process implying the grade 11 learners understood the concepts taught.

Alex and Mammen (2012) study revealed that majority of the grade 10 learners" gained and moved to Van Hiele level 3 from level 2 when their geometrical thinking level in view of the Van Hiele theory was determined. The survey study had a sample of 191 from five senior secondary schools in Eastern Cape in South African. In another study by Atebe (2008), 36 mathematics learners were the subjects for the study. He investigated South African and Nigerian students" conceptual understanding of quadrilaterals and triangles. The method used involved identifying and naming shapes, sorting of shapes, stating the properties of shapes, defining shapes and establishing class inclusions of shapes. Atebe (2008) results showed that majority of the subjects were on Van level 0.

In Nigerian, Atebe and Schäfer (2008) research concluded that several students in higher grades do not have the prerequisite skill to follow the content of the higher grade geometry curriculum. The study was conducted in Nigerian and South African mathematics learners where the researchers compared Grade 10, 11 and 12 learners of the two countries on van Hiele geometric thinking. The sample used was 139 students who wrote the van Hiele geometry tests. The findings showed that 68 learners from Nigeria completed the test while in South Africa 71 learners took part in the test. In Nigeria thirty six (36) or 50% were at the prerecognition level, 15 students attained level 1, 16 students attained level 2, 1 student attained level 3 and none at level 4. For South Africa twenty nine (29) students achieved the pre-recognition level, 16 students achieved at level 1, 17 were at level 2, 2 were at level 3 and 4 achieved at level 4.

2.5 Studies on Van Hiele Theory in Ghana

Armah et al. (2017) posited that teachers" geometrical competencies are very critical to the effective teaching of geometry. Their study aim was to determine the van Hiele Levels of geometric thinking reached by Ghanaian pre-service teachers before leaving for their Teaching Practice. The study sampled 300 second year pre-service teachers from 4 Colleges of Education. The pre-service teachers wrote the van Hiele Geometry Test during their second year, first semester. The following results were recorded for the various van Hiele Levels. For the records, 27% of pre-service teachers attained Level 1, 32% attained Level 2 while 17.67% of pre-service teachers attained Level 3. However, only 6% and 1% of Pre-service Teachers attained Levels 4 and 5 respectively. Also, 16.33% of pre-service teachers attained van Hiele Level 0. Their results showed that 75.33% of pre-service teachers" van Hiele Levels are lower than that expected of their future Junior High School 3 learners (Baffoe and Mereku 2010). Armah, et al (2017) suggests that most of the pre-service teachers" geometry knowledge is not sufficient to teach at basic schools geometry.

Baffoe and Mereku (2010) used a sample size of 188 from Winneba Senior High and Zion Girls Senior High both in Winneba metropolis. Baffoe and Mereku (2010) study aimed at measuring Ghanaian Senior High School (SHS) 1 students geometric reasoning level. The Van Hiele"s levels of geometric thinking were administered to the students when they were four weeks old in their respective Senior High School campuses. The findings from the Van Hiele test analysis revealed that 59%, 11%, 1% of Ghanaian SHS 1 students attained Van Hiele levels 1, 2 and 3 respectively. Baffoe and Mereku (2010) infer from the emanated results of the study and concluded that Ghanaian SHS 1 students were far behind in achievements when compared to their colleagues from other countries in geometric thinking.

Asemani et al. (2017) study was done in three (3) municipalities in the Central Region of Ghana. The sample used was 200 Ghanaian Senior High School final year students. The breakdown of the sample composed of 56% females and 44% males. After the quantitative analysis it was realised that 42.5% of the students did not meet any Van Hiele Geometric thinking level. Further analysis by Asemani et al. (2017) revealed that 33% of the final year students reached Van Hiele level 1. The attainment for levels 2, 3 and 4 were 22.5%, 1.5% and 0.5% respectively.

In their contributions to knowledge Salifu, Yakubu, and Ibrahim (2018) conducted a research with subjects from E. P. College of Education, Bimbilla, Ghana. The aim of their study was to determine PSTs geometric thinking level. The population used was 473 level 200 Pre- Service Teachers (PSTs) representing 82 (17.3%) science students and 391 (82.7%) representing general programme students. The sample size was 351(74.2%) of the population with 133 (37.89%) female and 218 (62.11%) male. Convenient and simple random sampling techniques were adopted in selecting the college and the general programme PSTs respectively. The main instrument used was the Van Hiele Geometry Test (VHGT). From the results, lowest mark was 3.0, highest mark 16.0, modal mark of 8.0, mean mark of 8.79 and standard deviation 2.49 were noted. Further analysis revealed that 37.3% did not reach any of the VHGT levels. Also, 32.5%, 20.8%, 8.0% and 1.4% attained levels 1, 2 3 and 4 respectively. Also no PST reached level 5. Salifu et al.(2018) recommended that tutors of colleges of education in Ghana should adopt practical approaches in teaching geometric concepts.

In Armah et al. (2018) study used pre-test post-test quasi-experimental design to investigate the effect of van Hiele Phase-based Instruction (VHPI) on Ghanaian Pre-service Teachers‟ (PTs‟) geometric thinking in terms of the van Hiele Levels. The study used 75 PTs each in the control group and the experimental group. Data was collected through Van Hiele Geometry Test (VHGT). The PTs in the experimental group were taught two-dimensional geometry using VHPI while the control group was taught by the traditional approach. The results from the Chi-square showed that the PTs in both groups had gained in their post-VHGT as compared to the pre-VHGT. Though the PTs in the experimental group performed better than those in the control group ($\chi 2 = 58.949$, $p<0.05$) in the geometric thinking. Again, when the paired samples t-test was analyzed it indicated a significant difference in mean scores between control and experimental groups($t=30.776$, $p<0.05$). Their study favored the PTs in the experimental group. Significant improvement was recorded in the performance of the experimental group because they were more PTs at level 3 and 4 than at levels 0, 1 and 2, which recommend that the VHPI served a useful pedagogical approach, impacted positively on PTs geometric thinking levels and has the possibility of improving teaching and learning of geometry in schools than the conventional approach.

Salifu (2018) conducted a study that investigated the Mathematics Pre-service Teachers (MPST) Van Hiele levels of geometric thinking in the 3 Northern regions of Ghana. The study used all the five Mathematics / Science Colleges of Educations. The subjects for the study were 298 MPST from Upper East, Upper West and Northern regions of Ghana of which 50 (16.8%) were female and 248 (83.2%) were male. Both purposive and simple random sampling techniques were used in the study. The MPST were given Van Hiele Geometry Test (VHGT) during their second year second semester. The analysis results revealed that 150 (50.3%) reached Van Hiele Level 0, 70 (23.5%) attained Van Hiele Level 1, 44 (14.8%) reached level 2 and 27 (9.1%) achieved Van Hiele Level 3. Finally, 7(2.34%) and 0 % attained VHL 4 and 5 respectively. Salifu (2018) concluded that only 34 (11.44%) were qualified to teach at the basic school geometry in Ghana. He also, said a majority of 264 (88.56%) attained between level 0 and level 2. Salifu (2018) recommended that Geometry teaching in the Colleges of Education in Ghana should be based on Van Hiele phase-based learning.

2.6 Gender

There is growing interest around the world on studies on gender differences in mathematics performance (Doris, O‛neill, & Sweetman, 2013; Kim & Law, 2012). Also, Yailagh (2005) stress that gender is a vital factor in mathematics learning as cited by Halat (2008). This argument has motivated me as a researcher to assess this variable in this study. Halat (2008) also cited Lloyd et al. (2005) research work that has shown that there are differences between achievement of male and female students in different content areas of mathematics such as computation, measurements, problem solving and spatial visualization.

The following researchers (Isiksal & Cakiroglu, 2008; Savas & Duru, 2005) have underscored the role of gender in learning mathematics. However, research studies indicated that gender difference is also connected to the grade level (Asante, 2010). Based on the literature review, it can be concluded that research studies regarding gender differences in some affective variables are inconclusive and need more attention. Researchers (Leder & Taylor, 2005; Leeson, 2005; Malone & Miller, 2003) have all indicated that the gender differences in Mathematics achievement is not conclusive because there are so many other factors that accounts for Mathematics achievement, such as poor attitude and lack of interest. This suggests that differences in gender are due to the individual"s perception of one"s ability and the sex role (Schiefele & Csikszentmihalyli, 2005).

According to these researchers (Alacacı & Erbas, 2010; Clewell & Campbell, 2002, Soleymani & Rekabdar, 2016) empirical studies have discovered that males are more likely to outperform females. Also, Clewell and Campbell (2002) have affirmed that, by emphasising that these occurs especially in the area of spatial geometry, problem solving, geometry, measurement, analytic geometry, reasoning, mathematics applications, proportionality and trigonometry. Clewell and Campbell (2002) went further to state that females are more likely to outperform males during elementary and middle school years on computation. Leahey and Guo (2001), Mullis, Martin, Gonzalez, and Chrostowski (2004) have stated that gender difference is either weak or does not exist in elementary and middle school but exists mostly in high school and college. According to Halat (2008) who also cited Lloyd et al. (2005) said that many research findings have showed that gender differences in Mathematics are varied.

2.7 Gender Difference in Favour of Female Students

A study on computation and spatial visualization by Armstrong (1981) revealed that female students perform better than their male counterparts. Also, literature elsewhere by Hydea and Mertzb (2009) indicates that female students" performance has been better than their male counterparts. Similarly, Ezeh (2005) used a quasi-experimental design with 240 senior secondary form two students as the sample comprising 130 males and 110 females. The aim of the study was to study the effect of delayed formalization approach on the subjects" achievement in sequences and series. The study was undertaken in Obollo Education Zone of Enugu State in Nigeria. Ezeh"s analysis showed that male students lagged behind their female colleagues. Ezeh

(2005) concluded that delayed formalization approach improved students‟ achievement in mathematics. In another study, Ogbonna (2007) revealed that female students performed better than male counterparts after he conducted the study among 290 J S III students. A quasi-experimental design method was adopted with two constructivist instructional models implemented. The purpose of the study was to investigate the effect of achievement and retention in Number and Numeration with gender as a variable. From Ogbonna‟s (2007) findings, it was discovered that students who were taught the two constructivist instructional models accomplished and retained higher than students who were taught the conventional method.

Kwame et al. (2015) reported in their study that even though female in the mixed-sex schools achieved better results than their male counterparts, the difference was not statistically significant. But there was significant difference in achievement of boys and girls in elective mathematics in the single-sex schools, which was in favour of the female students. Kwame et al.(2015) further revealed female superiority over their male counterparts during the study period when comparison between all male and all female students‟ achievement test scores in elective mathematics was computed. The purpose of Kwame et al. (2015) investigated differences between male and female students achievement in Elective Mathematics in some selected schools in Central and Western regions of Ghana. The sample composed of two (2) single-sex female schools, two (2) mixed-sex schools and two (2) single-sex male schools from seventeen (17) Senior Secondary Schools.

In a survey model, a quantitative research design used by Karapınar and Alp İlhan (2018) indicated a sample of 161 students from three different schools of National Ministry of Education located in the districts of Melikgazi and Kocasinan in Kayseri province. The breakdown of the sample is as follows, 61 students from Erciyes Secondary School, 48 students from Mehmet Tarman Secondary School, and 52 students in secondary school in Nuh Mehmet Yamaner Anatolian Imam Hatip High School. The sample consisted of 83 female and 78 male students. The authors stated that their aims of the study were to determine 8th grade students‟ Van Hiele levels of understanding geometry and to examine their knowledge on geometric objects in terms of Van Hiele levels of understanding geometry. The instruments were Van Hiele Geometry Test and the Geometric objects Achievement Test to collect the data of the study. Karapınar and Alp İlhan study used convenient sampling techniques to select the schools. Their study results revealed that the students who participated in the research were found to be lower compared to what they are expected to have at the present.. They concluded that when the data were analyzed by gender variable, there were significant differences in favor of girl students for both tests.

2.8 Gender difference in favour of Male Students

In a study, Olmez and Ozel (2012) reported that secondary school males were significantly more anxious than females. That study reported diverse findings; for example, it was found out that 15-year old Belgian females participated in the 2003 Programme for International Students Assessment (PISA) survey felt less efficacious than males (Ferla, Valcke, & Cai, 2009). An analysis of TIMSS mathematics data indicated that US eight grade male students had higher mathematics self-efficacy than female students (Louis & Mistele, 2012).

In a recent research, Peters (2013) reported that male college algebra students‟ mathematics self-efficacy scores were significantly higher than females‟ scores. In another study meta-analysis of 187 studies on gender differences in academic self-efficacy (Huang, 2013), significant gender difference between -1.60 and 1.40 in terms of effect size with a mean of .08 was found out. It was observed that in mathematics, males" self-efficacy scores were significantly higher with a mean effect size of .18 (Huang, 2013).

The purpose of Issahaq (2018) recent study at E. P. College of Education, Bimbilla was to examine gender differences in mathematics achievement among Pre-service teachers. The researcher used descriptive cross-sectional design study. The sample was 30 Pre-service teachers college sampled through stratified and simple random sampling techniques for the study. The instruments used to collect the data were questionnaire and test items. The researcher adopted quantitative analyses via descriptive (frequency counts, percentages, mean, standard deviation) and inferential statistics (independent samples t-test) via Statistical Product and Service Solutions (SPSS) version 21. Issahaq (2018) results indicated that there was a significant gender differences in mathematics achievement among the Pre-service teachers ($p \leq .05$) as the male Pre-service teachers outperformed their female counterparts in mathematics test. The researcher suggested that weak foundation in mathematics in addition to negative perceptions and attitudes of Pre-service teachers towards mathematics primarily accounted for the gender differences in mathematics achievement among the Pre-service teachers. The study finally recommended that mathematics tutors in E. P. College of Education- Bimbilla should give female Pre-service teachers" equal opportunities in the classroom to enhance their confidence in mathematics. Issahaq (2018) recommended the use appropriate media and teaching methods which are grounded in learner centred pedagogies to make mathematics learning meaningful to the Pre-service teachers.

A research that was undertaken by Kyei et al. (2011) in the Upper East Region of Ghana examined the expected causes of gender difference in the performance of mathematics among boys and girls in mixed senior high schools. Data was collected via questionnaire and interviews. The analysis indicated that male performed better than their female counterparts, as it was evident that girls‟ lack of self-confidence was a contributing factor or a major cause of the difference in performances. Students‟ interest in mathematics was influenced by personal interests and teaching methods as reported by the researchers. In a similar study, Moreno and Mayer (2009) on gender differences, the subjects responded to open-ended problem solving questions. Their study suggested that males outperform females in solving a problem. This was also buttressed by Fennema‟s (2005) findings that indicated males outperform females when tasks involves the cognitive skills used in Mathematics. The above findings are upheld by the other studies (Gallagher & Lisi, 2004; Patterson, Decker, Eckert, Klaus, Wendling & Papanastasiou, 2003) which discovered that male students are able to solve implicit problems and problems that do not require particular strategies because they have a more positive attitude towards Mathematics than female students.

Gavor (2014) revealed that, out of the 59,400 candidates who sat for the Elective Mathematics examinations, only 27.4% of females obtained the pass grades of A1 to E8 as compared to 70.5 % of their male counterparts. There were, however, limited differences in the pass rates of males and females with regard to Core Mathematics. Out of the total number of candidates who sat for the Core Mathematics examinations, the pass rates for males and females were 35.6% and 35.5% respectively. In 2013, whereas the pass rates for males and females in Core Mathematics were 40.0% and 31.7% respectively, the pass rate for Elective Mathematics for males and females were 54.3% and 23.1% respectively (WAEC, 2013).

A study in Ghana investigated sex differences in Mathematics performance among Senior High School by Asante (2010). Asante (2010) posited that "girls lacked confidence, had debilitating causal attribution patterns, perceived Mathematics as a male domain, and were anxious about Mathematics"(p.2). Asante (2010) concluded there was a significant difference between the attitudes and performance of males and females in Mathematics. He went further to say female students were identified to have exhibited low self confidence in Mathematics than their male counterparts.

2.9 No Gender Difference between Male and Female students

Nonetheless, other studies highlighted that the difference between females and males are getting smaller. Birgin, Baloglu, Catlioglu, and Gurbuz (2010) have stated that some studies reported no difference or minimal differences between males and females mathematics anxiety levels. Similarly, Michelli (2013) study revealed that no gender difference was detected between mathematics achievement test scores of 5th graders. Kiran and Sungur (2012) studied gender difference in science self-efficacy and strategy use of middle school students. Their analyses of the data from 1932 students showed no gender difference regarding science self-efficacy and strategy use. Similarly, Nyala (2008) showed that there was no gender difference between female and male students" attitudes towards mathematics at junior high school level. There is no consensus regarding gender differences in mathematics anxiety. A number of studies reported females are more anxious about mathematics than males (Bonnstetter, 2007).

Halat (2006) study determined gender differences in the acquisition of their geometric levels. Halat (2006) concluded that there was no statistical difference between male and female students when the VHGT was used to collect data. Again, as established by Halat (2008) there was no statistical difference in geometric reasoning levels and means between male and female learners when the VHGT was used. Also, Arhin and Offoe (2015) study was to find gender differences among Senior High School form one student"s problem-solving abilities. Their study conclusion was that there were no gender differences among the males and females subjects in problem-solving abilities when they were tested.

Salifu (2018) recommended that the traditional approach to teaching Geometry at Colleges of Education in Ghana should include Van Hiele phase-based approach. The following levels of reasoning stages or levels for both sexes were recorded as follows in the study. Those who attained level 0, were (Female =42.1% and Male = 34.4 %); level 1, were (Female = 30.1% and Male = 33.9%); level 2, were (Female = 19.5% and Male = 21.6%) ; level 3 were (Female = 6.8% and Male = 8.7 %); level 4 were (Female =1.5% and Male = 1.4 %) and level 5 both had 0 (0 %). The purpose of the Salifu (2018) study used Van Hiele theory levels to examine gender differences in geometric reasoning levels and gender differences in achievement scores of Preservice Teachers (PSTs). The research used six null hypotheses and one research question. The sample used was (351) 74.2% of the population. The sample composed of 133 (37.89%) female PST and 218 (62.11%) male PSTs of E. P. College of Education, Bimbilla-Ghana. Salifu (2018) employed both purposive and convenient sampling for the study. The test items used were 25 Van Hiele Geometry Test (VHGT) as the main instrument. From the overall analysis the results indicated that there was no significant difference in all the VHGT levels between the male and female PSTs when the independent sample t-test was used. However, the male PSTs out performed slightly better than their female counterparts in all the levels except only in level 4 which favored the female PST.

Halat and Şahin (2008) study was between pre- and in-service elementary school teachers in geometry, whose purpose was to investigate the reasoning levels of pre- and in-service elementary school teachers in geometry. The sample for the study was 186 pre-and in-service Turkish elementary school teachers. Pre-service elementary school teachers constituted 82 consisting of 34 (41%) male and 48 (59%) female while the in-service elementary school teachers were 104 including 61 (59%) male and 43 (41%) female. The pre- service elementary school teachers completed the third year of their college years. The in-service elementary school teachers had different years of teaching experience from 1 to 21 years at public schools. Convenience sampling procedure was adopted. The research took place in a city of Afyonkarahisar, located in the west part of Anatolia in Turkey. Data was collected during the spring of 2006 and at the end of the spring semester for the pre- and in-service elementary school teachers respectively. The researchers gave the pre- and in-service elementary school teachers a geometry test called Van Hiele Geometry Test (VHGT) that consisted of 25 multiple-choice geometry questions. While the pre-service elementary school teachers took the Van Hiele Geometry Test (VHGT) in their classes at the end of the spring semester, the in-service elementary school teachers took the VHGT at their work places during the school day. The quantitative data was analysed by employing the independent samples t-test with $\alpha = .05$. The study revealed that the pre- and in-service elementary school teachers showed the first four van Hiele levels, visualization, analysis, ordering and deduction in different percentiles and that there was no difference in terms of reasoning stages between the pre- and in-service elementary school teachers. Furthermore, the study revealed that there was no gender difference found regarding the geometric thinking levels between male and female in-service elementary school teachers.

Mbacho and Changeiywo (2013) conducted a research entitled "Effects of Jigsaw Cooperative Learning Strategy on Students" Achievement by Gender Differences in Secondary School Mathematics in Laikipia East District, Kenya". The study was also conducted because there was inadequate gender difference research conducted in Kenya on effects of the use of Jigsaw Cooperative learning Strategy on students" achievement in mathematics. The aim of their study was to address the problem of ineffective instruction methods by teachers by trying to find out if the use of Jigsaw Cooperative learning Strategy during teaching of Surds and further logarithm in mathematics to Form Three students had effects on their gender differences in performance. The design used for their study was non-equivalent control group design. The instrument used to collect data was mathematics achievement test (MAT). T-test was employed to test hypotheses at Coefficient alpha (ά) level of 0.05. The researchers stated that there is no statistically significant gender difference in mathematics achievement when students are taught using Jigsaw cooperative learning strategy.

In the Brong-Ahafo Region of Ghana, a study was conducted by Tetteh et al. (2018) to determine gender differences in performance in mathematics among Pre-service Teachers in the region. The study adopted the convenience sampling with a sample of 100 Pre-service Teachers consisting of fifty males and fifty females selected from level 200. The design for the study was a descriptive survey. T-test was used to analyze the data using the SPSS. The t-test conducted showed males ($M = 62.90$, $SD = 8.440$) do not have higher level of performance in mathematics than females ($M =66.84$, $SD = 7.000$); $t(98) = 0.606$, $P = 0.546$ (two-tailed), $d = .05$ in the public college. The analysis revealed that there was no significant difference in gender performance. In a similar study, Mokhtar (2000) reported that there was no significant difference in mean problem-solving achievement between male and female students.

2.10 Defining Attitude

The definition of attitude depends on the purpose of the definition (Papanastasiou, 2000). Koballa and Glynn (2007) define attitude as "a general and enduring positive or negative feeling about some person, object, or issue" (p.6). This definition implies that attitude is always formed towards something or a person based upon how an individual perceives it and it can be towards a subject of study or a teacher as in a classroom situation. Capraro (2001) defined Mathematics attitude as "those beliefs formed from a combination of experiences measured in the domains of mathematics" p. 8).

According to Zan and Di Martino (2007) student"s attitudes towards mathematics is defined as the emotional response either positive or negative associated to mathematics, confidence to succeed in studying mathematics, and strategies in coping with mathematical problems. Generally, attitude towards mathematics refers to the feelings towards mathematics lesson. Attitude like most abstract terms in English language has more than one meaning hence lacks a precise definition. However, references can be made to some few writers on mathematics. Nabie (2002) defines attitude as one"s feeling towards a particular object or class of objects. Development of students" attitudes towards geometry spans over a considerable long period of time and have powerful impacts on students effective engagement, participation and achievement in mathematics. Attitudes are product of experiences and can be altered and not innate. Attitudes towards mathematics became more negative as students progressed through their school years (K-12) (Aiken, 1979).

2.11 Definition of Mathematical Attitude

An Attitude towards mathematics survey is similar to an attitude towards geometry survey. The only difference between them is that the geometry survey emphases geometry and not on mathematics in general. In referencing attitude, one is generally referring to someone"s basic like or dislike of a familiar target (Hannula, 2002). There are two basic approaches to defining attitude towards mathematics according to Di Martino and Zan (2001): (a) a simple definition describes it as the degree of affection associated with mathematics and (b) a three component definition distinguishes emotional response, beliefs, and behavior as components of attitude.

2.12 Attitude Variables

Eagly and Chaiken (1993) claimed that there are three main components of attitude and they are the cognitive component, the affective component, and the behavioural component. In this study the researcher is going by the affective one specifically, enjoyment, usefulness, and confidence. The definitions and explanations of these are as follows:

2.12.1 Enjoyment

According to Cavallo and Laubach (2001), enjoyment in science (or mathematics) refers to the cheerfulness or happiness learners feel resulting from their experiences in science (or mathematics). Also, Stipek (2002) stated that enjoyment refers to "how much they liked working on math task and how boring they found math to be" (p. 316). It can also be explained as how a user likes, enjoys or is fascinated in working or learning (Liu & Johnson, 1998). Stipek (2002) stressed that enjoyment and positive emotions foster behaviours that enhance learning. The author of this thesis adopted the definition of the enjoyment of Stipek (2002).

2.12.2 Usefulness

Wigfield and Eccles (2002) defined usefulness as " how a task fits into an individual's future plans, for instance, taking a math class to fulfill a requirement for a science degree." p. 95). Also, Atweh (2007) plainly reveals the importance of usefulness of mathematics with the following words and these words about the usefulness of Atweh (2007) were also adopted by the author of this thesis:

> "Here I argue that the usefulness of mathematics should not only be demonstrated by using examples from the real world of the student as applications of mathematics, but also mathematical knowledge should be developed through such activities. The development of mathematical knowledge through real world activities demonstrates the usefulness of mathematics at the same time as engaging students. Further, this engagement of mathematics with thelife of the student should be an engagement not only with the physical world and the economic world, but also with the social world; not only with the world as the student will experience as an adult, but their current world; it should aim at developing an understanding not onlyof mathematics but also an understanding of the world. Finally, such engagement should aim at not only reading the world but also,whenever possible, at transforming the world - even to a smalldegree". (p. 9).

Certainly, students have a greater prospect to apply and use some geometry topics they learnt in their daily life. Vanayan,White, Yuen, & Peter (1997) indicated that 5th graders believe in the usefulness of mathematics in daily life, much more than the 3rd graders. Armstrong and Price (1982) asserted that both male and female students in the 12th grade realize usefulness of mathematics as the most significant factor in deciding to take or not to take more mathematics. Likewise, Young-Loveridge, Taylor, Sharma, and Hawera (2006) study results supports the same finding. Young-Loveridge et al. (2006) elaborated that students consider usefulness of mathematics as a decisive factor for their daily life and future career formation. Kadijevich (2006) posited that mathematical attitudes are frequently saturated by either usefulness of mathematics or by self-confidence in mathematics. Therefore, in most mathematics curricula across the globe, it is stressed that students should be mindful of the usefulness of mathematics and geometry (NCTM, 1989).

2.12.3 Confidence

Confidence is significant in math since it makes students more sure of themselves when solving nonroutine problems and learning new concepts. It also affects students‟ enjoyment and interest in math; therefore, getting them more involved in the subject (Hart & Walker, 1993). Self-confidence is one of the attitudinal variables found to influence students‟ participation and achievement in mathematics,(Hannula, Maijala & Pehkonen, 2004). From the longitudinal study on self-confidence by Hannula, et al. (2004), they found that learning of mathematics is influenced by the students‟ mathematics related beliefs, especially self-confidence. It was concluded by Bae, Choy, Geddes, Sabble, & Snyder (2000) on their analysis of National Assessment of Educational Progress (NAEP) data trends that achievement gaps seem more narrowly correlated to attitudes than to course taking. Their study also revealed that females are less likely than males to think they were good at mathematics. Cann (2009) reported in a study that Wales‟s girls were more likely than boys to report feelings of anxiety and a lack of confidence in mathematics. The main reason for girls‟ low participation in mathematics is due to lack of confidence as documented by Jones and Smart (1995).

2.13 Students Attitude towards Geometry

In TIMSS 2003 pilot research with 89 seventh grade participants, it was indicated that attitude to mathematics was related to mathematics achievement (Kadijevich, 2003). Similarly, Nyala (2008) mentioned that students‟ attitudes towards a subject affect their achievement in that subject. Beside the studies of Kadijevich, (2003) and Nyala (2008) mathematics achievement and attitudes regarding gender differences were taken into consideration in many studies (Zan & Di Martino, 2007). The relationship between gender and affective variables (e.g., efficacy, anxiety and attitude) in elementary years has not been explored as thoroughly as that of the relationship between gender and mathematics achievement. Attitudes towards geometry are the important determinants of academic success and achievement. In order to succeed in a subject, positive attitude towards a subject is a necessary prerequisite. This also applies to mathematics, especially in case of girls as compared to boys.

Previous studies on mathematics reported that attitudes towards mathematics have important role in determining achievement on mathematics, and students with positive attitudes towards mathematic will have high scores in mathematics achievement (Guner, 2012; Tapia & Marsh, 2004; Zan & Di Martino, 2007). Yet, studies also reported that many students have poor attitudes towards mathematics still achieve higher marks (Goodykoontz, 2008).

Winter and O‟Raw (2010) opined that the construct attitude is more stable than emotions and feelings. Again, they said attitude are malleable and has influence on partaking, because attitudes are formed in response to teaching practices, curriculum, and organizational arrangements.

Mato and De La Torre (2010) results were confirmed in wider research, concerning math study attitude among the secondary school students. The study showed that those with better academic performance have more positive attitude towards mathematics than those with poorer academic performance. Mata, Monteiro and Peixoto (2012) argue that a positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject and, in a similar way, a negative attitude towards mathematics relates to a negative emotional disposition. Also, these researchers, Atanasova-Pacemska, Lazarova, Arsov, Pacemska, and Trifunov (2015) have also supported Mata et al. (2012) by an assertion that positive attitude towards mathematics reflects a positive self-confidence, enjoyment, value and emotional disposition in relation to the subject and, in a similar way, a negative attitude towards mathematics relates to a negative self-confidence, value, enjoyment and emotional disposition. Furthermore, Atanasova-Pacemska et al. (2015) indicated that one is expected to achieve better results in a subject that one enjoys, has confidence in or finds useful because these attitude dispositions have an impact on an individual‟s behavior in real life. Atanasova-Pacemska et al. (2015) went further to propose that positive attitudes towards mathematics are anticipated because they may influence one‟s readiness to learn and also the benefits one can derive from mathematics teaching.

Moenikia and Zahed-Babelanb (2010) research posited that students‟ attitudes toward mathematics affect how well or how often they do it, and how much enjoyment they derive from it. Moenikia and Zahed-Babelanb (2010) study hypothesized that there is a positive relationship between students‟ attitude to learn geometry and their achievement in geometry.

2.14 Negative Attitudes towards Mathematics

Lack of interests and negative attitudes towards mathematics were problems that should be encountered by students in learning mathematics, because mathematics is regarded as a difficult subject and obscure (Ganal & Guiab, 2014). Also, Özgün-Koca, and Şen, (2006), Taşdemir, (2009) and Ünlü (2007) revealed that the negative attitude towards mathematics increased when the grade levels increased. A case study was conducted in Nigeria by Ajai and Imoko (2015). Ajai and Imoko (2015) adopted a Problem-Based Learning (PBL) method in investigating gender differences in Mathematics achievement and retention scores. They reported that majority of students in Nigeria have developed negative attitudes for Mathematics because of the notion that Mathematics is reserve for exceptionally gifted students.

2.15 Positive Attitudes towards Mathematics

Some studies emphasized that males showed more positive attitudes towards mathematics than females (Michelli, 2013; Tasdemir, 2009). Sunzuma et al. (2013) study, explored secondary school student"s attitudes towards their learning of geometry. The study adopted a quantitative descriptive survey design using simple frequency and percentages in analyzing the data as part of descriptive statistics. A sample of 100 „O" level students were drawn, using stratified random sampling, from three urban high schools. The research was done quantitatively using a questionnaire that comprised of 15 closed questions which were adapted and then modified from Fennema and Shermann (1976). Mathematics Scale The study revealed that the students" attitudes towards the usefulness of geometry was positive and that many of them believed that geometry is a valuable and necessary topic which can help them in their future careers. The result also showed that the majority of the students in the Bindura urban, 80% did not like solving geometrical problems. It also emerged that geometry is not a difficult topic to both male and female students and that though most students did not like solving geometry; they considered geometry to be useful. In comparison to the female students, Asante (2012) reported that male students are more positive towards mathematics. The findings of Veloo, Nor, and Khalid (2015) reported that there is gender difference in students‟ attitude towards physics. Male students are more interested in Physics than the female students. In another similar research conducted in Ghana on sex differences in Mathematics among Senior High School students, Asante (2010) found that when compared with boys, "girls lacked confidence, had debilitating causal attribution patterns, perceived Mathematics as a male domain, and were anxious about Mathematics" (p.2). This confirms the assertion that male students have more positive attitudes towards the subject than female students. The low representation of women in Mathematics, Science and Technology programmes and professions in Ghana has been blamed on the negative attitudes and perceptions of women towards Mathematics, Science and Technology disciplines (Asante, 2010). Smith (2004) and Asante (2010) findings are contrary to Carroll and Gill (2011) findings which indicated that most female students of the University of Limerick in Ireland who participated in the study had considerable positive attitudes towards the subject than their male counterparts in the study.

Simegn and Asfaw (2018) study used a sample of 367 comprising of 240 grade 10 students and 127 grade 12 students of General Secondary and Preparatory School in Wolkite Town. The aim of their study examined the effect of students‟ attitude towards mathematics on the achievement of female and their male counterparts. Their study also examined the relationship between attitudes and mathematics achievement. Simegn and Asfaw (2018) selected the participants using stratified random sampling technique with Attitude towards Mathematics Inventory (ATMI) and achievement test as the main instruments to collect the data. Their data was analyzed using Descriptive Statistics, Multiple Linear Regression Models, Independent samples t–test, and Pearson Correlation Coefficient. The results, obtained from both grade levels, unveiled that students had positive attitude towards mathematics but at medium level, however, the level of female students was less than males.

2.16 Relationship between Mathematics achievements and Attitude towards Geometry

Numerous studies have been undertaken to try to reach an understanding of the relationship between student attitude towards mathematics and academic achievement (Fraser & Kahle, 2007; Mato & De la Torre, 2010; Nicolaidou & Philippou, 2003). Similarly, studies by the following respective authors (Bramlett & Herron, 2009; Ma & Kishor, 1997; Mohd, Mahmood & Ismail, 2011; Papanastasiou, 2000) work on relationship between students‟ attitude and the students‟ academic achievements show a positive relationship. Hence students‟ attitude towards mathematics is a significant factor that might influence the performance of the students. Due to this numerous studies (Bramlett & Herron, 2009; Falmer & Karasel, 2010; Fennema & Sherman, 1976; Köğce, Yıldız, Aydın, & Altındağ, 2009; Maat & Zakaria, 2010; Tahar, Ismail, Zamani & Adnan, 2010; Tapia & Marsh, 2004;) has been done in their respective countries in order to figure out the students attitude towards mathematics.

Aktaş and Aktaş (2012) used survey method to determined high school students‟ attitude towards geometry with respect to some variables in Ordu. The instrument used was “Geometry Attitude Scale” developed by the researchers. The sample used was 536 high school students. The recorded Cronbach α reliability coefficient was 0.89. Descriptive statistics such as standard deviation and mean value as well as independent sample t-test and one way Anova for group comparisons were used. There was significant difference between school type and students‟ branches at the end of the study. On the other hand, gender and grade recorded was not significant between them. The researchers suggested that future studies should focus on investigating attitudes towards geometry by choosing bigger sample from different cities of Turkey and the effects of new geometry curriculum on the students‟ attitudes towards geometry.

Mubeen, Saeed, and Arif (2013) study measured relationship of attitude towards mathematics with academic achievement in mathematics among 9th and 10th class secondary level students. The study used a sample of 500 students comprising 200 males and 300 females. Two female and two male schools in Pakistan were selected for the study. Data was analyzed and interpreted using correlation coefficient. The study result indicated that males differed in their mathematical achievement from females and that their attitude towards mathematics and achievement in mathematics did not go together.

Ünlü, Avcu and Avcu (2010) determined the relationship between geometry attitude scores and self-efficacy scores towards geometry. The participants were 126 pre-service elementary mathematics teachers. The study was conducted in Aksaray University Education Faculty in the 2010-2011 academic year where convenience sampling method was used. Correlational model was used in the process to analyse the data. The instruments used were "Self-efficacy scale towards geometry" developed by Cantürk-Günhan and Baser and "Geometry attitude scale" developed by Bindak. The researchers indicated that pre-service teachers‟ geometry attitude scores and self-efficacy scores towards geometry was high. Also, they recorded a strong positive relationship between self-efficacy beliefs towards geometry and pre-service teachers" geometry attitudes.

Tsao (2017) study explored pre-service elementary school teachers" attitudes toward learning of geometry where 56 participants completed the Likert scale of Utley Geometry Attitude Scales (UGAS). The UGAS subscale measured usefulness of studying geometry, confidence of learning geometry and the enjoyment of studying geometry. The study revealed that the pre-service elementary teachers" attitudes toward the usefulness of geometry were moderately positive and that many of them believed that geometry was a valuable and necessary topic which could help them in their future careers and education. The correlations among the three subscales were all statistically significant There appears to be a significant relationship between usefulness of studying geometry, enjoyment of learning geometry, and confidence of learning geometry in pre-service teachers. A significant relationship ($p < 0.01$) also appears to be between self-report grade and usefulness of studying geometry and confidence of learning geometry in pre-service teachers.

In a quantitative methodology study, Dede (2012) examined affective variables influencing students' attitudes towards geometry as they progress from grade 8 to 11. "Enjoyment", "Usefulness" and "Anxiety" were the attitude variables in the questionnaire. Dede"s study area was in Central Anatolia Region of Turkey where four primary schools and three high schools were sampled. Both descriptive and inferential statistics were used to analyse the data. A significance level of 0.05 was set for all inferential tests. The results of the study were: a) students, in general, enjoy geometry, b) have positive attitudes towards the usefulness of geometry, c) have, in general, high level of anxiety for geometry, and d) statistically, there exist significant correlations amongst attitude variables according to the grade levels.

Senol, Mine, and Koç, (2018) study investigated the relationship among seventh grade students‟ mathematics self-efficacy, mathematics anxiety, attitude towards mathematics, mathematics achievement, and gender and school type. The two-way ANOVA and multiple regression analysis were used to examine the difference and predicting mathematics achievement of seventh grade students. The findings revealed that there was a significant main effect of the constructs and mathematics achievement. However, school type did not have significant main effect on mean self-efficacy scores, anxiety scores, and achievement scores but have significant effect on attitude scores.

Yasar (2016) study used 1,801 students studying at different types of high schools whose purpose were to determine the attitudes of learners studying at different types of high schools towards mathematics classes, and to test whether or not there is a meaningful difference between the demographic properties of the learners and their attitudes. The results showed that the attitudes of the learners towards mathematics are at medium level, and that there is a meaningful difference between the attitudes of the learners towards mathematics classes and the education levels of their fathers and the learners‟ high school types. Also, there was no meaningful difference between the gender of the students, the gender of the mathematics teachers, attending to an extra course, receiving private lessons for mathematics, their perceived success status, educational levels of their mothers, the income level of their families, the number of siblings, the order of the student in the family as a sibling, fathers‟ and mothers‟ profession, and the attitudes of the students in the study. Multi Linear Regression

Analysis was performed with the purpose of determining the factors affecting the attitudes of the students in the study group, the Gender of the Mathematics Teacher (= -.073), the Profession of the Mother (= - .069) and the Educational Level of the Father (= .049) have effects in determining the attitudes of the students towards mathematics classes.

Similarly, in a recent study, Soleymani and Rekabdar (2016) stated that the effect of attitude on final grade was not statistically significant. The study purpose investigated the relationship between undergraduate students" mathematics achievement and attitudes toward mathematics.

Khun-Inkeeree, Omar-Fauzee, and Haji Othman (2016) study was done in Thailand. The government of that country noted that mathematics is one of the basic subjects needed in all sphere of endeavor. The results found that there is positive relationship between students" attitude towards learning mathematics and their achievement when 100 students from Songkla province in Thailand were the subjects. The study investigated the relationship between students" attitude towards mathematics and their achievements. The researchers stated that there was no difference between gender attitude and their achievement in mathematics. The result of the study implies that both male and female students have almost the same achievement in statistics because there was no significant difference in their achievement scores.

Larbi and Okyere (2014) documented that there was significant relationship between student attitude to using manipulatives and their mathematics achievement. A sample of 70 students from three intact classes were randomly selected from the Sunyani West Municipality. Their study investigated into the role of algebra tiles manipulatives and gender differences in learning and achievement in mathematics especially in algebra. Their study also showed no significant differences between boys and girls performance on the post test administered at the end of the treatment. Implications of their findings were discussed and recommendations made for classroom practices.

The findings from Bhowmik and Banerjee (2015) reported that there was a significant positive correlation between attitude towards mathematics and achievement in mathematics. Their study investigated high school students‟ attitude towards mathematics and achievement in mathematics. They employed a methodology known as descriptive type where 394 secondary (class ten) students from six different high schools participated in the study. The result was presented quantitatively using independent samples t-test and Pearson‟s correlation coefficient (0.05 significant levels). There was significant difference among boys and girls students regarding attitude towards mathematics.

Mensah, Okyere and Kuranchie (2013) study used a sample of 100 students and 4 teachers. The students were randomly selected while the teachers were purposively sampled. Specifically, it determined the relationship between Mathematics teachers‟ attitudes and students‟ attitudes toward Mathematics, and identify the effect of student and teacher attitudes on students‟ performance in Mathematics. The instruments were two sets of questionnaires used to gather data from the respondents after they had been validated and their reliability established. The study was fashioned to extend the discussion to the influence of teacher attitude on student attitude. The achievement scores were from students‟ end of term examination scores, used as a measure of students‟ academic achievements. The study reported a significant relationship between teacher attitude and student attitude toward Mathematics. It also revealed that teachers" positive attitude radiated confidence in students, hence made them develop positive attitude towards the learning of Mathematics. The results of the study were also consistent with existing finding of Cann (2009) on the relationship between teacher attitude and students" performance in Mathematics

Kundu and Ghose (2016) concluded in their correlational study in 2016 that High Secondary students" attitude towards mathematics and their achievement in mathematics was high. The sample used was 784 students both male and female of Class XI selected from southern district of West Bengal. Modified Fennema and Sherman (1976) Mathematics Attitude Scale and Mathematics test were used to obtain the data. Their study was based on a survey of High Secondary school students attitudes towards mathematics and its possible effect on achievement in the subject.

Kaur (2016) study used a sample of 453 participants comprising of 223 males and 230 females from government adolescent schools in Chandigarh. Kaur (2016) study scrutinizes the achievement in mathematics of ninth class government school students in relation to their attitude towards mathematics. A self-developed and standardized achievement test and Attitude towards Mathematics scale were used as the main instruments for data collection. The results showed that achievement in mathematics of adolescents studying in government schools has significant and positive correlation with different dimensions (self-confidence, motivation, usefulness, teacher"s expectations and enjoyment) attitude towards mathematics. The study concluded that there is significant difference in achievement in mathematics of ninth class government school students in relation to their attitude towards mathematics.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter covered the following topics: research design, quantitative approach, qualitative approach, variables, location of study, study population, sample size, sampling procedure, research instruments, questionnaires, other instruments used in assessing the Van Hiele Levels and multiple-choice tests used to measure geometric thinking levels. The rest are pilot study, validity, reliability, data collection procedure, data analysis, ethical consideration and limitations of the study.

The study was designed to answer the following research questions and hypotheses:

1. What are the geometric reasoning levels of PSTs" in Colleges of Education in Northern Region by gender ?
2. What are PSTs" in Northern Region attitudes towards geometry by gender ?
3. What is the relationship between PSTs" in Northern Region achievement score and attitude towards geometry by gender?

The main hypotheses are as follows:

1. There is no significant difference between female and male PSTs" VHGT achievement scores.
2. There is no significant difference between female and male PSTs attitude towards geometry.
3. There is no relationship between PSTs" VHGT achievement scores and their attitude towards geometry.

3.1 Research Design

Burns and Grove (2009) explained research design as an outline for conducting a study with control over factors that may influence the validity of the findings. Also, Polit and Beck (2012) understand research design as the complete plan of finding answers to research questions. Therefore, in order to find answers to the research questions, the researcher adopted a cross sectional survey design to draw both quantitative and qualitative data for the analyses. A cross-sectional survey according to Alhassan (2012) comprises of collecting data at one point and over a short period to provide a 'snapshot' of the outcome and the characteristics associated with a population at a specific time. The rationale for embracing this design is that it depends on large-scale data from a representative sample of a population with the goal of describing the nature of existing conditions. Vogt (2007) stressed that using cross sectional design offers advantages in terms of economy and the probability to sample a large population. The cross-sectional survey was employed to investigate gender differences in pre-service teachers" Van Hiele"s geometric reasoning levels using VHGT and their attitude towards geometry. A mixed method approach specifically concurrent method was employed where both qualitative and quantitative data were collected together. Creswell (2010) explained mixed methods as research whereby the researcher combines both elements of quantitative and qualitative approaches that aimed at getting breadth and depth of understanding and corroboration. The two approaches are explained below.

3.2 Quantitative Approach

Van Rensburg (2010) explained quantitative approach in research as the collection of numerical data through formal, objective, systematic process in which information is obtained about the phenomenon under investigation. Creswell (2003) also asserts that a quantitative approach is a process where a researcher uses post positivist predetermined instruments to collect statistical data for developing knowledge. Creswell (2003) went further to state that " quantitative methods are used chiefly to test or verify theories or explanations, identify variables to study, relate variables in questions or hypotheses, use statistical standards of validity and reliability, and employ statistical procedures for analysis" (p.2). Babbie (2004) also argued that quantitative approach observations are more explicit, easy to put together to compare and summarize data. He went further to say that quantitative approach makes it possible to the use of statistical analyses which includes simple averages to complex formulaes and mathematical models.

3.3 Qualitative Approach

Creswell (2009) explained qualitative research as process of comprehending a social or human problem through building a complex, holistic picture, fashioned with words, reporting detailed views of informants and conducted in a natural setting. Denzin and Lincoln (2003) stated that "the word qualitative implies an emphasis on the qualities of entities and processes and on meanings that are not experimentally examined or measured (if measured at all) in terms of quantity, amount, intensity or frequency" (p.10). Also, Brynard and Hanekom (2005) explained that descriptive data which is generally people"s own written in words or verbal narration is refered to as qualitative research. Denzin and Lincoln (2003) stated that "Qualitative research stresses the socially constructed nature of reality, the intimate relationships between the researcher and what is studied, and the situational constraints that shape inquiry" (p.10). Streubert, Speziale, and Carpenter (2003) stressed that qualitative researcher looks for multiple realities the participants" will present as their viewpoints. They also advanced the argument that in conducting qualitative research limits disruption of the natural context of the phenomenon under study. They went further to say that acknowledgement of the subjects in the research process, and presenting data in a literary style rich with participants" commentaries. The qualitative method was also adopted in this study because it enabled the researcher to explore learners" attitude towards geometry. In this study, the researcher paid attention to the narratives of the participants. The qualitative approach allowed the researcher to concentrate on the viewpoints of the participants in order to understand what is influencing them to display their attitudes towards geometry.

3.4 Variables

The variables in this study were categorized as independent, intervening and dependent.

Independent variable : The Gender of PSTs (Female and Male)

Intervening variables : The PSTs attitude towards geometry (Usefulness, Confidence and Enjoyment)

Dependent variable: The PSTs VHGT scores

3.5 Location of the study

The location of the research was in the northern region of Ghana. The region has a population of 1,820,806 representing 9.6 % of Ghana"s total population with a total landmark coverage area of 70,383 square kilometres. The region shares boundaries with upper east and upper west to the north, the Brong Ahafo and Volta regions to the south, and two neighbouring countries , the republic of Togo on the east and La Cote d'Ivoire to the west. The region has 26 administrative districts. The study was carried out in the Sagnarigu district, Nanumba North municipality, and Tamale metrolis. The region has only one university known as University for Development Studies, with the following 5 teacher colleges of education namely E.P. CoE, Bimbilla, Bagabaga COE-Tamale, Tamale CoE, GambagaCoE, and St. Vincent CoE, Yendi. Also, it has a total of 84 senior high schools.

3.6 Population

Hayes (2011) defined population as the entire people in which the researcher is interested and to which he or she would like to generalize the results of a study. The population of the study was all level 200 PSTs of Northern Region CoEs, Ghana. The region has five (5) CoEs namely E. P. CoE, Bimbilla, Bagabaga COE-Tamale, Tamale CoE, Gambaga CoE, and St. Vincent CoE, Yendi. The Tamale, Gambaga and Bagabaga CoEs are owned by the state while E. P. and St. Vincent CoEs are mission Colleges supported by government. Specifically E. P. College is owned by Evangelical Presbyterian church of Ghana whereas St. Vincent also owned by the Catholic church. The population for the study was one thousand, six hundred and sixty-nine (1669) PSTs of level 200. The population composed of four hundred and sixty-seven (477) female representing 28% and one thousand two hundred and two (1,192) male representing 72%. The distribution of the population for each college is presented in Table 6.

Table 6: Population for each college

S.No	College	Number of Male	Number of Female	Total
1	E.P. Bimbilla	340	74	414
2	Tamale	325	188	513
3	Bagabaga	372	137	509
4	Gambaga	105	68	173
5	St.Vincent	50	10	60

Source: Institute of Education –UCC,(2019)

3.7 Sample Size

Sampling is taking a portion of the population of a study as a representation of the whole population (Seidu, 2015). The sample for the study was drawn from 3 CoEs namely

E. P. Bimbilla, Bagabaga, and Tamale. A sample of two hundred and forty (240) representing 14.38% of the targeted 1669 PST was used for the study. The sample composed of two hundred and forty (240), comprising 120 PSTs each of female and male. The sample was arrived at considering the number of female and male PSTs of the colleges who agreed to be used as the subjects for the study after generating the random numbers from Microsoft excel. The detailed distribution of the sample for each College is presented in Table 7.

Table 7: Distribution of the sample for each college

S.No	College	Number of Male	Number of Female	Total
1	E.P. Bimbilla	40	42	82
2	Tamale	54	54	108
3	Bagabaga	26	24	50
	Total	**120**	**120**	**240**

Source: Field Data. (2019)

Eighty-two (82) representing 19.81% made up the E. P. College of Education, Bimbilla, sample. The sample of Tamle College was 108 (21.05%) and that of Bagabaga College was was 50 (9.8%). The average age of the sample was 22.5 years, median 22 years, mode 21 years, minimum age 17 and maximum age 31. The age range is 14.

3.8 Sampling procedure

The sampling procedure was convenient, stratified and simple random. The convenient sampling method was used to select the CoEs for the study. Convenient sampling was used because the researcher could easily reach out to those Colleges, the distance between them are not so wide apart. In this study, stratified sampling was also used to obtained the gender balance. The students were first stratified into categories or strata: by gender or sex group (male and female). The stratified sampling was used because the researcher needed to have both gender in the sample. Specifically, non-proportional stratified sampling was used to select equal number of male and female for the study. Simple random sampling technique was then used to select the pre-service teachers" from the respective Colleges. Seidu (2015) comprehends simple random sampling as a sampling method that provides equal opportunity for all participants in a population for selection. In this study computer generated simple random numbers was used to represent the index numbers of the selected PSTs.

3.9 Research Instruments for the Study

The two (2) instruments that were used to gather the necessary data to ascertain PSTs geometric reasoning and attitude towards geometry were the questionnaire and the 25 VHGT items.

3.9.1 The VHGT Items

One of the research instrument used was the VHG achievement test. The entire 25 multiple choice items of VHGT (See Appendix D) developed by Usiskin (1982) was administered to the PSTs to measure their geometric thinking levels. The VHGT questions are ordered sequentially into five (5) subgroups such that it starts from the very simple item to the very difficult item. Each subgroup covered the Van Hiele"s geometric thinking level. The VHGT is most standard and has been used by most researchers (Abdullah & Zakaria, 2013; Armah et al, 2017, Asemani et al, 2017; Baffoe & Mereku, 2010; Fuys, et al 1988; Halat, 2008; Hoffer, 1983; Mayberry, 1983; Salifu, 2018; Usiskin, 1982;) to assess students" geometric thinking.

The first set of five (1-5) questions entails identification of shapes, naming of shapes and comparing of geometric shapes such as rectangles, squares and triangles, that constituted level 1 concepts. The next set of five questions (6-10) are for level 2 and included recognizing and naming properties of geometric shapes or figures. Questions (11-15) deal with the logical order of the properties of figures or shapes previously recognized in level 2, and the relationships between these properties, are for level 3. Level 4 questions measure deduction and proof, axioms, theorems and, postulates which is numbered (16-20). The last and final five subtest questions 21-25 are for measuring the understanding of the formal aspect of deduction, such as establishing and comparing Mathematical system.

3.9.2 Questionnaires

Questionnaires contained prepared documents of items designed to elicit responses from participants for understanding the research problem under study (Babbie, 1990). In this study, the Utley Geometry Attitude Scales (UGAS) that was developed by Utley (2007) was adapted for use. The UGAS was developed after extensive review of a variety of existing instruments used to measure attitudes towards mathematics. The UGAS was designed to measure the attitudes of undergraduate college students toward geometry. The said attitude questionnaire was used to measure the following construct namely, enjoyment in learning geometry topics, valuation of learning geometry and confidence towards learning geometry. The attitude questionnaire contained personal data of the PSTs such as name of college, level, age, programme, native region and gender.

The actual questions were 32 closed ended questions requiring their responses and three open ended questions. The closed ended items consisted of positive and negative statements. The UGAS, a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree), was used to measure the PSTs attitude towards geometry (See Appendix E) . It contains seventeen (17) positively and fifteen (15) negatively worded questions. Items 1, 4, 6, 7, 10, 11, 13, 16, 19,21, 22, 24, 25, 27, 29, 30 and 32 were the positive statements wheareas items 2, 3, 5, 8, 9, 12, 14, 15, 17, 18, 20, 23, 26, 28 and 31 were negative statements. Negatively worded items were recoded prior to analysis. The instrument is designed such that higher scores are more indicative of an overall higher attitude toward geometry. Ten (10) items listed from 1 -10 constituted the first construct refered to as usefulness of learning geometry. Twelve (12) items listed from 11 -22 constituted the second construct called confidence in learning geometry. The third construct which sort to measure enjoyment of learning geometry consisted of ten (10) items listed from 23-32. The ratio of total sum of the respondents (240) to the total items (32) exceeded the minimum level suggested by Nunnally and Bernstein (1994) and Chua (2009) who stated that the number of respondents should be at least five times more than the number of items. So in this study, 32 items were used in the study, thus the sample size should be at least 32 multiply by 5, which produces a minimum sum of 160.

3.10 Other Instruments used in assessing the Van Hiele Levels

It is a difficult task in assessing levels of geometric thought because learners may not be at the same level for different concepts (Battista, 2007; Pusey, 2003). Research has indicated that a multiplicity of instruments have been designed to assess the learners" levels. Notable ones are (Usiskin,1982) multiple-choice tests, open-ended tasks (Smith & De Villiers, 1989), interviews (Atebe & Schäfer, 2008; Burger & Shaunessy, 1986; Fuys et al., 1988; Mayberry, 1983) and proof tests (Senk, 1989). Fuys et al. (1988) have indicated that most of the assessments only focus on the performance of the learners at a certain stage while some studies (Atebe and Schafer, 2008; Chew and Lim, 2013; Abdullah and Zakaria, 2013; Abu and Abidin 2013) also focuses on the progress that a learner makes in response to the teaching.

3.11 Multiple-choice tests used to measure geometric thinking levels

From review of literature there exist a variety of multiple-choice tests based on geometry developed by Hendricks (2012), Mogari (2004), Van Putten (2008), and Watson (2012) for measuring geometric thinking levels. One test that has been used regularly is a test developed by Usiskin (1982) and the Cognitive Development and Achievement in Secondary Schools Group (CDASSG) (Halat, 2008). The obligation to be able to determine the level of geometric thought of learners led Usiskin (1982) to develop a 25 question multiple-choice test. However, these authors (Crowley, 1990; Smith & De Villiers, 1989; Wilson, 1990) raised reservations as to whether reasoning could be tested with the items used in the test. Smith and De Villiers (1989) based their apprehension on their findings after comparing the multiple-choice test with open-ended question tests. Nevertheless, the test has been used in many great studies (Abdullah & Zakaria, 2013; Armah et al, 2017, Asemani et al, 2017; Baffoe & Mereku, 2010; Fuys et al. 1988; Halat, 2008; Hoffer, 1983; Mayberry, 1983; Salifu, 2018; Usiskin, 1982;) and has also been used as the footing for setting up comparable tests.

Rodriquez and Haladyna (2013) opined that reasoning could actually be assessed by carefully wording the questions in the multiple-choice tests. Brown (2002) has said that setting of excellent multiple-choice tests can be very challenging and time-consuming and it is a continually a good practice to pilot the test before using it to determine the validity of the test. The results could be skewed due to learners guessing the answers from multiple-choice tests which could be countered by adding more test items (De Villiers & Njisane, 1987) and carefully selecting the answers so that the correct choice is not so obvious (Brown, 2002). According to Battista (2007), despite the criticism, the multiple-choice test method of the Van Hiele levels has been used extensively because it is easy to administer, far less time consuming than any of the other methods and is more practical to use when large number of learners must be assessed.

3.12 Pilot Study

Hallway and Jefferson (2007) in their study explained pilot study as a smaller version of the proposed research and is conducted to refine the questionnaire. The purpose of pilot study is to assist the researcher to identify possible hitches in the study and allows the researcher to revise the instrument before the actual study is conducted. In order to increase the validity of this study, the 25 VHGT and the 32-items questionnaire developed by Utley (2007) were first piloted in St. Vincent College of Education, Yendi and Gambaga College of Education in the Northern Region. The programme level and age group of pre-service teachers in the pilot study and that of the final group study were almost the same. In the pilot the participants first answered the questionnaire before the VHGT.

3.13 Validity

Validity as explained by Seidu (2015), is the extent to which the research instrument serves the purpose for which it is intended for. Face validity was done by giving the instruments to the researchers‟ two colleagues in the Mathematics Department of the E. P. College of Education, Bimbilla for their comments and suggestions. The two tutors consulted the Colleges of Education Geometry course outlines by the Institute of Education, UCC-Ghana as well as some Mathematics text books for Colleges of Education in order to validate the test items. Hence the tutors conducted both face and content validation of the instrument. The tutors concluded that it met the pre-service teachers‟ standard. Face validation involved checking the appropriateness of the language and test structure dimensions of the instrument. The researcher‟s main supervisor and research methods lecturer also subjected the VHGT and the adapted Utley questionnaire to both face and content validity.

3.14 Reliability

The reliability of a test or instrument define by Creswell (2010) refers to the extent to which the test or the instrument consistently measures what it is supposed to measure. Joppe (2000) also explained reliability as the extent to which results are consistent over time and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. One characteristics of reliability is that if the instrument is repeated under the same condition and it produces similar results then the instrument is considered to be reliable. Researchers (Atebe & Schafer, 2008; Baffoe & Mereku, 2010; Burger & Shaughnessy, 1986; Salifu, 2018; Usiskin, 1982) have acknowledged the VHGT as well known and established instruments that has been used in several research works because it is reliable and valid over the years. Kuder-Richardson formula 20 method was used to estimate the reliability coefficients. Reported reliability estimates of the VHGT ranged from 0.69 to 0.78. In order to measure the reliability of the test items thirty (30) PSTs were used in the pilot test on the 5th February 2019. These PSTs were not participants in the main study. The Kuder-Richardson formula 20 method was used to determine the reliability coefficient of the VHGT which resulted in coefficient of 0.72. This value indicates a high degree of reliability of the test. The following reliability coefficients were recorded for the various levels. Level 1, 2, 3, 4 and 5 had 0.48, 0.40, 0.30, 0.43 and 0.10 respectively.

A measure of internal consistency was calculated for the 32 item UGAS and each of its subscales. Seventy-five (75) of the PST from the mentioned pilot Colleges answered the questionnaire. The internal consistency using Cronbach"s coefficient alpha was 0.84 for the usefulness subscale, 0.76 for the confidence subscale, and 0.68 for the enjoyment subscale. For the total UGAS score using the 32 items that comprised the three subscales, internal consistency reliability analysis revealed a Cronbach"s coefficient alpha of 0.80 which is good for administring.

3.15 Data collection Procedure

A written permission request was sent to Prof. Zalman Usiskin for his approval and advice for the use of his test items before administering the test (see Appendix A). In order to find answers to the research questions for this study, the PSTs took the test in the 2018/2019 academic year, first semester dated 7th February to 14th February , 2019. The VHGT items were given to the PSTs to answer with a duration of 45 minutes. The specific dates they wrote and answered the questionnaires in the sampled Colleges were as follows on 7th February 2019 in E. P. College , Bimbilla, Bagabaga College on 12th February 2019 and Tamale College on 14th February 2019. At E. P. College of Education in Bimbilla, the Principal and Vice were informed even before the introductory letter from the university arrived. At Bimbilla where the researcher teaches, two of his colleagues assisted him in the administration of the test and the questionnaire. At Bagabaga College , the Vice Principal was given the introductory letter and he also assisted the researcher in administrating the test and questionnaires. At Tamale College the ICT tutor received the letter and also assisted in administering the instruments. The PSTs filled the questionnaire before taking the VHGT.

3.16 Data Analysis

This study used two grading systems: First grading method: Each correct answer to the VHGT 25-item multiple-choice (see Appendix D) was scored 1 mark, for marking scheme (see Appendix F). Hence, each Preservice Teacher"s score ranges from 0 –25 marks. Second grading method: there are two different cases that can be used in assigning Levels to students namely, the Classical Case and the Modified Case. The second method of grading the VHGT was based on "3 of 5 correct" success criterion suggested by Usiskin (1982). By this criterion, if a Pre-service Teacher answered correctly at least 3 out of the 5 items in any of the 5 subtest within the VHGT, the Pre-service Teacher was considered to have mastered that level. Using this grading system developed by Usiskin (1982) the learners were assigned weighted sum scores in the following manner as shown below:

1. If at least three questions (between 1 and 5) are answered correctly: 1 point
2. If at least three questions (between 6 and 10) are answered correctly: 2 points
3. If at least three questions (between 11 and 15) are answered correctly: 4 points
4. If at least three questions (between 16 and 20) are answered correctly: 8 points
5. If at least three questions (between 21 and 25) are answered correctly: 16 points 0 point is scored if a student gets 2 out of 5 correct answers.

For a student to progress from one level to another then the student needs to answer correctly at least three of previous level questions in order to be assigned a level. For instance; a student who was able to correctly answer three questions from 1 to 5, correctly answer two questions from 6 to 10, correctly answer three questions from 11 to 15, gets 1 point from first level, 0 point from second level, 4 points from third level respectively making a total of 5 points. Even though Van Hiele‟s level 3 criterions was met by this student, he cannot be placed in Van Hiele‟s level 3 because the student failed to answer correctly at least three of second level questions (Usiskin ,1982). Also, a score of 7 indicates that the learner met the criterion at Levels I, II and III (i.e.1+ 2 + 4 = 7). The method of calculating the weighted sum makes it possible for a person to determine upon which van Hiele Level the criterion has been met from the weighted sum alone. The second grading system served the purpose of assigning the learners into various van Hiele Levels based on their responses. Usiskin (1982) stated that a student can score a maximum mark of 31 and the minimum mark of 0 from the VHGT. The 32 item and 3 fill in opened ended attitude questionnaire towards geometry was also given to the PSTs to answer within 30 minutes.

Data collected were analysed both qualitatively and quantitatively. Qualitative data were obtained from the open-ended questionnaire items answered by the pre-service teachers. The data were grouped into different categories/themes consistent with the research objectives and deduction and generalizations made using patterns and trend of responses (see Appendix B). Quantitative data were obtained from the VHGT (see Appendix D) and the questionnaire (see Appendix E) items answered by the pre-service teachers from the likert scale. The negatively worded items were recoded where 1= 5, 2=4, 3=3, 4=2 and 5=1. The quantitative data were entered in the computer using SPSS program version 16 and excel 2013 consistent with Armah et al., (2017), Asemani et al., (2017), Atebe (2008), Baffoe and Mereku (2010), MayBerry (1983), and Usiskin (1982) studies. Specifically, the data were analyzed using independent sample t-test , bivariate correlation and simple descriptive statistics: percentages, means and frequencies. The data was presented with the aid of tables and charts. The assumptions for the independent sample t-test are as follows

- The t-test was used to determine the significance of the difference between the male and female group means.
- The t-test was used to analyze the interval data.
- The t-test was also used because the sample size was more than 30
- The t-test was also used because the sample was picked from a normally distributed population with homogeneity of variance.

- The t-test was also used because the simple random technique was used to select the sample.

Finally, the assumption for the bivariate correlation was that, it is used to evaluate the degree of relationship between PSTs achievement score and attitude towards geometry by gender.

3.17 Ethical Consideration

Churchill (1995) stated that " Ethics is the study of moral principles and values which govern the way an individual or group conducts its activities" (p. 26). An authorization letter was obtained from the graduate school of University of Education, Winneba through the department of Mathematics of University of Education, Winneba to conduct the research Permission was also sought from the principals and Vice Principals of the sampled Colleges to allow the research to be conducted in their Colleges. The Bagabaga College approval letter can be found in (see Appendix A). The Vice Principals were given the letter after a discussion about the possible date for administering of the instruments were agreed. Before administering the instruments, the researcher talked to the heads of Mathematics & ICT department and pre-service teachers who were involved in the study in order to create a rapport. The information collected was kept confidential and used only for the purposes of the study. None of the PSTs was forced to participate, and the identity of every participant was kept under strict confidentiality. Hence, participants were not asked to write their names but rather use the numbers assigned to them and their Colleges. The researcher was honest in his dealing with all participants and was mindful of their personal cost such as an affront to dignity, embarrassment, lost of trust, and lowered self-esteem. The researcher kept research work visible and was opened to suggestions. In addition, the following precautions were taken. (1) the researcher did not abuse his position as someone in authority (2) the researcher ensure sensitivity to all people such as ethnicity, gender, culture, religion and personality.

3.18 Limitations of the study

In the Van Hiele‟s multiple-choice tests some answers were chosen by the PSTs by mere guess work because some students got the "3 out of 5" answers correct in level 3 but could not meet level 2 criterion. Also, the open-ended attitude towards geometry questionnaire given to the PSTs was an attempt to reduce the effect of guessing the yes and no options. PSTs were expected to supply reasons for their choice but a few PSTs did not supply reasons for their yes/no answers which was not encouraging. Again, out of the 46 Colleges of Education in Ghana, only 3 were sampled for this study which has restricted the scope of this study. Hence, the findings of this study cannot be generalized to all PSTs in Ghana. Finally, data collection was a difficult exercise to do because one College Tutor did not want his teaching period to be used even after he was informed of the exercise and time. His claim was that , it was the only period for the week for him. Despite these challenges, the researcher followed the due process to ensure that the finding of this research reflects the reality on the ground.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this study was to investigate gender differences in PSTs" Van Hiele"s geometric reasoning levels and their attitude towards geometry in terms of usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry. Also, relationship between PSTs" VHGT achievement scores and their attitude towards geometry were investigated. The findings of the study and discussion of the findings are presented in six sections according to the research questions and hypotheses.

4.1 Research Question 1: What are the geometric reasoning levels of PSTs' in Colleges of Educationin Northern Region by gender?

Table 8 shows the VHGT reasoning levels of PSTs presented according to gender with frequency and percentages in one decimal place attached to each level. The classification of the levels was based on the "3 of 5 correct" success criterion suggested by Usiskin (1982).

Table 8: The overall Van Hiele reasoning levels attained by both female and male PSTs'.

Group	Previsuliazation Level 0	Visualization level 1	Analysis Level 2	Deduction Level 3	Order Level 4	Rigor Level 5
Female	7 (5.9%)	21 (17.5%)	67 (55.8%)	25 (20.8%)	0(0.0%)	0(0.0%)
Male	5 (4.2%)	23 (19.2%)	21 (17.5%)	66 (55.0%)	4(3.3%)	1(0.8%)
Total	**12 (5.0 %)**	**44 (18.3%)**	**88 (36.7%)**	**91 (37.9%)**	**4(1.7%)**	**1(0.4%)**

Source: Field Data. (2019)

For the female PSTs reasoning levels, 7 representing 5.9% of the PSTs attained level 0, while 5 (4.2%) of the male PSTs also attained level 0. In all, a total of 12 (5.0 %) male and female PSTs were in that level meaning they could not identify geometric figures based on their appearances. Twenty-one (21) of the female PSTs also representing 17.5% attained level 1 against 23 (19.2%) for the male PSTs. This implies that 44 male and female PSTs representing 18.3% were at Visualization stage (level 1) where geometric figures were identified based on their appearance. Also, 67 (55.8%) females achieved level 2 while 21 males PSTs representing (17.5%) attained that level. The analysis level (Level 2) was on the ability of PSTs to analyze figures geometrically and it revealed that 88 (36.7%) of both gender were able to reason at that level. For Deduction level, 25 female PSTs representing20.8% attained that level while 66 (55.0%) of the male achieved that level. Deduction level (Level 3) is about classes of shapes rather than individual shapes.

From Table 8, 91 (37.9%) of both gender PSTs reached that level criterion. At this level students are suppose to see shapes go together with their properties. Also, no female PST got to levels 4 and 5 while the male PSTs reached those levels with 4(3.3%) and 1(0.8%) respectively. These levels sort to examine how students work with abstract statements about geometric properties and make conclusions based more on logic than intuition and also apply Non-Euclidean geometry. The modal level for the female PSTs reasoning level was level 2 (Analysis), where PSTs recognize the properties of the shapes but the properties are independent of one another. Also, the modal level for the male PSTs reasoning level was level 3 (Deduction) where students are supposed to develop relationship between properties, identify hierarchy of properties and shapes. The reasoning levels by the PSTs were abysmally low and not encouraging, especially, with the female PSTs.

4.2 Research Question 2: What are PSTs' in Northern Region attitudes towards geometry by gender?

Table 9 is the 5-point likert scale responses which were regrouped into agree, neutral and disagree. The strongly agree and agree were put together as agree while strongly disagree and disagree were also put together as disagree. The result is presented in terms of frequency and percentage covering all the 32-items from the UGAS. This sort to find out PSTs" attitudes towards geometry by gender. The attitudes in terms of usefulness of learning geometry, confidence of learning geometry and enjoyment of learning geometry are presented according to females and males.

Table 9: Frequency and percentage distributions of female and male PST responses on their attitude towards geometry.

S/No.	Statement	Gender	Agree Number and Percentage	Neutral Number and Percentage	Disagree Number and Percentage
1	I believe that I will need geometry for my future.	Female	83 (69.7%)	13 (10.9%)	23 (19.3%)
		Male	91 (75.8%)	12 (10.0%)	17 (14.2%)
2	Geometry has no relevance in my life.	Female	20 (16.9%)	14 (11.9%)	84 (71.2%)
		Male	10 (8.3 %)	13 (10.8 %)	97 (80.8 %)
3	Geometry is not a practical subject to study	Female	33 (28.7%)	6 (5.2 %)	76 (66.1%)
		Male	13 (11 %)	4 (3.4 %)	101 (85.6 %)
4	I can see ways of using geometry concepts to solve every day problems.	Female	73 (62.4%)	17 (14.5%)	27 (23.1%)
		Male	80 (67.8 %)	13 (11%)	25 (21.2 %)
5	Geometry is not worthwhile to study.	Female	34 (29.1%)	13(11.1%)	70 (59.8%)
		Male	8 (6.7 %)	12 (10.1%)	99 (83.2 %)
6	I often see geometry in everyday things.	Female	61 (51.7%)	16 (13.6 %)	41 (34.7%)
		Male	86 (72.3 %)	14 (11.8 %)	19 (16.0%)
7	I will need a firm understanding of geometry in my future work.	Female	76 (64.4%)	15 (12.7%)	27 22.9%)
		Male	84 (70.6 %)	13 (10.9%)	22 (18.5 %)
8	I do not expect to use geometry when I get out of school.	Female	24 (20.2%)	13(10.9 %)	82 (68.9%)
		Male	12(10.1 %)	11(9.2%)	96 (80.7 %)
9	I will not need geometry for my future.	Female	29 (24.6%)	18(15.3 %)	71 (60.2%)
		Male	12(10.1 %)	13(10.8 %)	95 (79.2 %)
10	Knowing geometry will help me earn a living.	Female	80 (67.8%)	13 (11.0 %)	25 (21.2%)
		Male	71(59.2 %)	26 (21.7 %)	23 (19.2 %)
11	I am sure that I can learn geometry concepts.	Female	95 (79.2%)	9 (7.5 %)	16 (13.3%)
		Male	97 (81.5 %)	9 (7.6 %)	13 (10.9 %)

12	I often have trouble solving geometry problems.	Female Male	73 (60.8 %) 61 (51.3 %)	15 (12.5%) 19 (16.0 %)	32 (26.7%) 39 (32.8%)
13	I am confident I can get good grades in geometry.	Female Male	84 (70.0 %) 92 (77.3 %)	12 (10.0%) 17 (14.3 %)	24 (20.0%) 10 (8.4 %)
14	When I cannot figure out a geometry problem, I feel as though I am lost and cannot find my way out.	Female Male	54 (45.4%) 58 (49.2)	20 (16.8 %) 20 (20.9 %)	45 (37.8%) 40 (33.9 %)
15	I lack confidence in my ability to solve geometry problems.	Female Male	54 (45.4%) 38 (32.2 %)	7 (5.9%) 10 (8.5 %)	58 (48.7%) 70 (59.3 %)
16	I feel sure of myself when doing geometry problems.	Female Male	63 (52.5%) 84 (70.6 %)	24 (20.0 %) 19 (16.0 %)	33 (27.5%) 16 (13.4 %)
17	For some reason even though I study, geometry seems unusually hard for me.	Female Male	62 (52.1%) 55 (46.2 %)	18 (15.1 %) 17 (14.3 %)	39 (32.8%) 47 (39.5%)
18	Geometry problems often scare me.	Female Male	43 (37.1 %) 35 (29.7 %)	14 (12.1 %) 17 (14.4 %)	59 (50.9%) 66 (55.9%)
19	I am confident that if I work long enough on a geometry problem, I will be able to solve it.	Female Male	95 (79.2%) 106 (89.1 %)	7 (5.8%) 3 (2.5%)	18 (15.0%) 10 (8.4%)
20	Geometry examinations usually seem difficult.	Female Male	70 (58.8%) 54 (45.4 %)	15 (12.6 %) 21 (17.6%)	34 (28.6%) 44 (37.0 %)
21	I can usually make sense of geometry concepts.	Female Male	86 (72.9%) 89 (75.4 %)	14 (11.9%) 16 (13.6%)	18 (15.3%) 13 (11.0 %)
22	I have a lot of confidence when it comes to studying geometry.	Female Male	67 (55.8%) 83(70.3 %)	19(15.8%) 20(16.9%)	34 (28.3%) 15(12.7%)
23	Geometry problems are boring.	Female Male	34 (29.1%) 28 (23.5%)	23 (19.7%) 11 (9.2%)	60 (51.3%) 80 (67.2 %)
24	When I leave class with a geometry question unanswered, I continue to think about it.	Female Male	85 (72.6%) 97 (80.8%)	9 (7.7%) 8 (6.7%)	23 (19.7%) 15(12.5 %)
25	When I start solving a geometry problem, I find it hard to stop working on it.	Female Male	59 (50.0%) 65 (54.2 %)	16 (13.6%) 17 (14.2%)	43 (49.1%) 38 (31.7%)
26	Time drags during geometry class.	Female Male	57 (49.1%) 58 (48.3%)	22 (19.0 %) 24 (20%)	37 (31.9%) 38 (31.7%)
27	Geometry is fun.	Female Male	48 (40.7%) 56 (47.1%)	18 (15.3%) 20 (16.8%)	52 (44.1%) 43 (36.1 %)
28	I just try to get my homework done for geometry class in order to get a grade.	Female Male	79(67.5%) 73 (60.8%)	18 (15.4%) 16 (13.3 %)	20 (17.1%) 31(25.8 %)
29	Geometry is an interesting subject to study.	Female Male	71 (62.3%) 93 (77.5 %)	15 (13.2 %) 14 (11.7 %)	28 (24.6%) 13 (10.8 %)
30	Solving geometry problem is enjoyable.	Female Male	65 (55.6%) 87 (72.5 %)	15 (12.8 %) 14 (11.7 %)	37 (31.6%) 19 (15.8 %)
31	Working out geometry problems does not appeal to me.	Female Male	46 (43.2%) 25(20.8%)	21 (17.8 %) 19 (15.8 %)	51 (43.2%) 76 (63.3%)
32	Geometry has many interesting topics to study.	Female Male	79 (66.9%) 90 (75.0%)	15 (12.7%) 18(15%)	24 (20.3%) 12 (10.0%)

From Table 9, almost 70% of female PST indicated that geometry was useful because they believed that geometry would be needed for their future work. Again, majority (67.8%) of the female PSTs agree that they can apply geometry concepts in solving everyday problem . Also, majority (68.9%) of the female PSTs indicated that geometry will help them earn a living after school.

Further analysis has found that female PSTs indicated that they have confidence in learning geometry with the confirmation as displayed in Table 9, where 95 (79.2%) of female PSTs indicated that they are sure they can learn geometry concepts. Also 70% of them responded that they are confident they can get good grades in geometry. A majority representing 79.2% agreed they have confidence that if they work on a geometry problem for a longtime they will be able to solve it. On the issue of whether PSTs enjoy learning geometry, majority of PSTs representing 72.6% responded that if they leave a class with a geometry question unanswered, they will continue to think about it. Also,some of the female PSTs agree that they just try to get their homework done for geometry class in order to get a grade, as responded by 67.5% and finally, 66.9% said that geometry has many interesting topics to study.

For the male PST responses, it is discussed in order just like their female counterparts. Out of 120 male PSTs, 91 agree that they believe that they will need geometry for their future work. Also, 80 PSTs representing 67.8 % agree they can use geometry concepts to solve everyday problems. Furthermore, 59.2%. of the male PSTs agreed that knowing geometry will help them earn a living in life. The following were also recorded for the male PSTs confidence level in learning geometry as shown in Table 9. Out of 120 PSTs, 81.5 % of them indicated that they can learn geometry concepts. Also, 92 representing 77.3 % agree that they have confidence that they can get good grades in geometry and finally on this construct 106 PSTs representing 89.1% agree that they have confidence that if they work long enough on a geometry problem, they will be able to solve it.

The following were also recorded for the enjoyment of learning construct for the male PSTs. Majority representing 80.8% responded that when they leave class with a geometry question unanswered, they continue to think about it. Also, 73 of the male PSTs indicated that they just try to get their homework done for geometry class in order to get a grade. Finally, 75.0% of male PSTs said that geometry had many interesting topics to be studied.

To support the above analysis, the open-ended statements on usefulness of learning geometry, confidence of learning geometry and enjoyment of learning geometrywere put into themes and tabulated in Table 29 and Table 30 (see Appendix B) for female and male PSTs respectively.

For the female PSTs when they were asked "Is learning geometry useful in real life?" under the yes and no options. 82.5% of female PSTs said yes that learning geometry was useful, 14.2% said no and 3.3% left it blank. The most common reasons given for yes responses by most respondents were (i) It is useful in solving everyday problems, (ii) It is applicable to everyday life and (iii) To know and identify shape. Below is a vivid response to the usefulness of learning geometry from a PST, when that question was asked.

> *" Yes, learning geometry is useful in real life because you can as well apply the concept in your everyday life. And when you apply the concept you have learnt, it can as well help you earn a living".* (respondent number 068).

Again, female most common reason for the no responses was that it has no link to everyday problems. Below is a captured response from a PST who maintained that , " *I do not see any link it has with my future*", when the question was asked, (respondent number 122).

For the female PSTs when they were asked "Do you have the needed confidence to learn geometry?" for the yes and no options. 47.5% responded yes, 44.2% ticked no and 8.3% left the question blank. The most common reasons they advanced for the yes option among most participants were (i) I always perserve to learn geometry, (ii) It is practical subject and (iii) My favourite subject. Below is a response to that question by a PST who maintained *"Because am good in calculation in terms of geometry so I have the confidence to learn geometry" ,*(respondent number 40).

Again from the female PSTs the most common reason for the no responses from most PSTs were as follows (i) difficult to understand geometry (ii) I hate it (iii) It is confusing and boring and (iv) Weak foundation. A PST maintained that *"Because I am always facing difficulties whenever solving geometric problems and as a results , the confidence level is very low",* (respondent number 109).

When the female PSTs were asked "Do you enjoy learning geometry?", 49.2% indicated yes, 41.7% responded no while 9.1% abstained from answering the question. The most common reasons for the yes option among most respondents were (i) motivated to solve geometry problem, (ii) it improves my critical and logical thinking, (iii) it is practical and (iv) it is fun and interesting. A sample response from a PST when that question was asked is:

> *"Immediately I was introduced to geometry, I developed interest in it because the concept in it are link. One concept leads you to another that makes it enjoyable to whenever I am learning it",* (respondent number103).

On the contrary, the most common reasons given for the no answer from majority of the participants were as follows; (i) difficult to understand geometry, (ii) it is confusing and boring, and (iii) it is difficult because of so many rules and properties. A captured sample response from a PST stated that,

> *"It is boring and needs a lot of efforts and this can hinder you from learning other subjects which can result in my failure. I don't even enjoy maths in particular",* (respondent number 057).

For the male PSTs Table 30 (see Appendix B) shows the most common reasons for usefulness of learning geometry, confidence of learning geometry and enjoyment of learning geometry. For the questions on whether male PSTs see geometry useful in real life, 87.5% indicated yes, while 7.5 % responded no and 5 % of PSTs left the question blank. The most common reasons given for the yes answers among majority of the PSTs were as follows; (i) It is useful in solving everyday problems, (ii) it is applicable to everyday life, (iii) promotes critical thinking and (iii) it helps me to identify shapes and their properties. Below is a sample response from a PST to the question "Is learning geometry useful in real life?".

> "*This is because it helps one to be a critical thinker. It also helps one to employed at end his /her learning programme. It helps to solve everyday problems",* (respondent number 033).

On the contrary, the most common reasons given for the no answers by majority of the respondents were (i) It is not useful for me and (ii) geometry is not applicable in life. Below is a sample response from a PST who maintained that, "*I study geometry a lot but I have never apply it somewhere in my life. I like the way profit and lost is reality in life*", (respondent number 015).

Also the male PSTs most common responses when they were asked, "Do you have the needed confidence to learn geometry?" for the yes and no options, 73.3% responded yes, 18.3% ticked no and 8.3% left the question blank. The most common reasons they advanced for the yes option were (i) easy to understand geometry, (ii) I always perservere to learn geometry, (iii) Because am always motivated to solve geometry problem, (iv) It is fun and interesting and (v) It is Practical and based on concrete materials. One PST maintained that,

> "*Because it is practically oriented, it is some times easy to understand. Other concepts are being explained using concrete materials which aid in memory"*, (respondent number 070).

On the contrary, the male PSTs most common reasons for the no responses among majority of the PSTs were (i) difficult to understand geometry and (ii) it is confusing and boring. A sample response from a PST is captured below.

> "*Because it is sometimes difficult to analyze and apply the methods and rule to solve the geometry*", (respondent number 068).

When the male PSTs were asked "Do you enjoy learning geometry?", 68.3% indicated yes, 24.2 % responded no, while 7.5% abstained from answering the question. The most common reasons for the yes option by majority of the participants were (i) it improves my critical and logical thinking, (ii) easy to understand, (iii) It is fun and interesting, (iv) Because am always motivated to solve geometry problem and (v) It is Practical and based on concrete materials. A sample response from a PST stated that, *"It makes learning interesting and avoid boredom. It is practical",* (respondent number 042).

On the contrary, the most common reasons for the no option by the male respondents were (i) difficult to understand geometry and (ii) it is confusing and boring. A sample response from a PST to the question is: "*Because I do not always understand the concepts and as a result, I do not develop any interest for it",* (respondent number 110).

From the analysis, both female and male PSTs have some common reasons to the open-ended questions. In conclusion , a wider margin in terms of yes answer response percentage was found in the PSTs confidence in learning geometry which was in favour of the male with a percentage difference of 25.8%. Also, 19.1% was found as a difference in PSTs enjoyment of geometry, again in favour of the male PSTs when the yes responses were computed. The usefulness of learning geometry construct was the closets between the gender groups because a difference of 5% was found between the gender groups yes answer responses. In all, the male PSTs showed a positive attitude towards geometry than their female counterparts.

4.3 Research Question 3: What is the relationship between PSTs' in Northern Region achievement score and attitude towards geometry by gender ?

To analyze research question 3, all the five levels VHGT scores were each correlated against PSTs usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry for both gender.

The bivariate correlational analysis for females is captured in Table 31 (see Appendix C). The correlation coefficients .061, .022 and .045 respectively were found between the female PSTs achievements in VHGT level 1 and their attitude on usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry. This shows a weak correlation between the female PSTs attitude and achievements in geometry in Van Hiele level 1. This bivariate correlation coefficients yielded non-significant p-values of .510, .812 and .624 corresponding to usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry respectively. Similarly, correlation coefficients between the female PSTs achievements in Van Hiele"s levels 2, 3, 4 and 5, and that of their attitudes on usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry were all very weak. Also, there was no statistically significant relationship in levels 2, 3 , 4, 5 between the female PSTs attitude and achievements in geometry since all the p-values were greather than .05.

Table 10: Female PSTs bivariate correlation of attitude against their achievements for all the levels.

	Attitude	Achievement
Pearson Correlation	*1*	*.066*
Sig. (2-tailed)		*.471*
N	*120*	*120*

From Table 10 there was weak correlation and no significant relationship between female PSTs attitude towards geometry and achievements with ($r(120) = .066$, $p = .471 > .05$) when all the levels achievements were correlated against the overall attitude towards geometry.

The PSTs male analysis as captured in Table 32 (see Appendix C) indicates very weak bivariate correlation between the male PSTs attitude and achievements. The correlation coefficients -.034, -.003 and -.079 were obtained for usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry respectively in VHGT level 1. The significant values in level 1 for usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry were .714, .972 and .393 respectively. These significant values are all greater than .05. Hence, no statistically significant relationship exists between the male PSTs attitude and achievements in level 1. Similarly, usefulness of learning geometry, confidence in learning geometry and enjoyment of learning geometry correlation coefficients for levels 2, 3, 4 and 5 are all less than .05 except usefulness at levels 4 and 5 and enjoyment at level 5. This results is suggesting a very weak correlation between the male PSTs attitude and achievements within the levels and the individual construct. Also, there was no statistically significant relationship in levels 2, 3 , 4, 5 between the male PSTs attitude and achievements in geometry since all the p-values were greather than .05.

Table 11: Male PSTs bivariate correlation of attitude against their achievements for all the levels.

	Attitude	Achievement
Pearson Correlation	1	.029
Sig. (2-tailed)		.757
N	120	120

From Table 11, there was weak correlation and no significant relationship between male PSTs attitude towards geometry and achievements with with (r (120) = .029, p = .757 > .05) when all the levels achievements were correlated against the overall attitude towards geometry.

In conclusion, there was weak correlation between PSTs attitude towards geometry and achievement scores when all the levels were computed together across gender. Also, there was no significant relationship between PSTs attitude towards geometry and achievements by gender.

The next section sort to identify if possible significant difference between female and male PSTs in level 1 through to level 5 of VHGT achievements.

4.4 Research Hypothesis 1:There is no significant difference between female and male PSTs' VHGT achievement scores

The main null hypothesis was therefore broken down into the following sub hypotheses to give a clear analysis.

1.1 Ho: There is no significant difference between female and male PSTs‟ VHGT achievement scores in level 1.

1.2 Ho: There is no significant difference between female and male PSTs‟ VHGT achievement scores in level 2.

1.3 Ho: There is no significant difference between female and male PSTs‟ VHGT achievement scores in level 3.

1.4 Ho: There is no significant difference between female and male PSTs‟ VHGT achievement scores in level 4.

1.5 Ho: There is no significant difference between female and male PSTs‟ VHGT achievement scores in level 5.

Table 12 is the cumulative frequency comparison of scores obtained by both female and male PSTs in the VHGT Item Test. The discussion will be done taking the number of female and male PSTs who scored below the average, the exact average score and scores above average with percentages. The first grading system was used here where each correct answer to the VHGT 25-item multiple-choice was scored 1 mark.

Table 12: Cummulative Frequency Table of scores obtained by both female and male PSTs in the VHGT Item Test.

Score	Female No. of students (N)	Female Cumulative (N)	Female (%)	Female Cumulative (%)	Score	Male No. of students (N)	Male Cumulative (N)	Male (%)	Male Cumulative (%)
4	1	1	.8	.8	6	1	1	.8	.8
5	4	5	3.3	4.2	7	4	5	3.3	4.2
6	1	6	.8	5.0	8	4	9	3.3	7.5
7	6	12	5.0	10.0	9	14	23	11.7	19.2
8	12	24	10.0	20.0	10	16	39	13.3	32.5
9	24	48	20.0	40.0	11	27	66	22.5	55.0
10	17	65	14.2	54.2	12	20	86	16.7	71.7
11	17	82	14.2	68.3	13	14	100	11.7	83.3
12	19	101	15.8	84.2	14	10	110	8.3	91.7
13	10	111	8.3	92.5	15	4	114	3.3	95.0
14	5	116	4.2	96.7	16	3	117	2.5	97.5
15	3	119	2.5	99.2	17	1	118	.8	98.3
16	1	120	.8	100.0	18	2	120	1.7	100.0
Total	**120**		**100.0**		**Total**	**120**		**100.0**	

From Table 12, the minimum and maximum marks achieved were 4 and 16 respectively for the female PSTs, while that of their male counterparts were also 6 and 18 respectively. It is surprising to observe 12 female and 5 male PSTs scoring between 4 to 7 out of a total score of 25. This performance is totally discouraging and the implication could be serious in the field for these PSTs. For example, such PSTs may not be able to handle geometry topics well. Also, 82 (68.3%) of the female PSTs scored below the halfscore of 12 while 66 (55%) of their male counterparts achieved that. Further analysis shows that 19 (15.8%) of the female scored exactly the half score while 20 (16.7%) of their male counterparts achieved that score. For those who scored above the half score, 19 (15.8%) for the female and 34 (28.3%) for male were found. The modal scores were 9 and 11 for the female and male PSTs respectively. This performance of the PSTs in the VHGT was very weak and alarming.

To further check the comparison performances of the PSTs by gender, Table 13 presents the number of correct and wrong answers with percentage analysis for VHGT level 1. The discussion will be done by presenting the number with percentages of female and male PSTs who correctly or wrongly answered questions 1, 2, 3, 4, and 5 respectively.

Table 13: Gender comparison of number of correct and wrong answers for level 1

	Female		Male	
Question	Number of Correct answers with Percentages	Number of wrong answers with Percentages	Number of Correct answers with Percentages	Number of wrong answers with Percentages
1	115 (95.8%)	5 (4.2%)	117 (97.5%)	3 (2.5%)
2	112 (93.3%)	8 (6.7%)	118 (98.3%)	2 (1.7%)
3	108 (90%)	12 (10 %)	84 (70%)	36 (30%)
4	71 (59.2%)	49 (40.8%)	76 (63.3%)	44 (36.7%)
5	40 (33.3%)	80 (66.7%)	43 (35.8%)	77 (64.2%)
Total	**446 (74.33%)**	**154 (25.66%)**	**438 (73%)**	**162 (27%)**

Table 13, shows the performance of the PSTs in level 1, where 115 (95.8%), 112 (93.3%), 108 (90%), 71 (59.2%), and 40 (33.3%) female PSTs had correct answer in items 1, 2, 3,4 and 5 respectively compared to their male counterparts who obtained 117 (97.5%), 118 (98.3%), 84 (70%), 76 (63.3%), and 43 (35.8%) correct answers in the same items respectively. Item 5 was a difficult one for both gender because they did not get 50% correct answers for that item. Both female and male PSTs performed well only in the first four items of subtest 1 because more than 50% of them had correct answers in items 1 to 4. The proportion of female PSTs correct answer was 74.33% while those with wrong answer was 25.67% whereas their male counterparts correct answer proportion for level 1was 73% and wrong answer proportion of 27% . The most easier item was question 1 for the female which was about identifying a square likewise the most easier item for the male was question 2 which had to do with identifying a triangle. The female correct answer proportion was in the decending order from question 1 to 5. For the male the decending order was from question 3 to 5. In level 1, a total of 154 (25.66%) wrong answers emanated from the female PSTs and 162 (27%) wrong answers from the male was noticed. Teachers need to do more work on visualization because some PSTs could not identify squares, triangles, rectangles and parallelograms. The main problem some of them encountered was when some squares, rectangles were tilted. Teachers should emphasis on shape spartial orientation when teaching geometric concepts. Activities like sorting and classifying shapes based on their appearance should be encouraged by teachers.

Sub research hypothesis 1.1: Ho: There is no significant difference between female and male PSTs' VHGT achievement scores in level 1.

Table 14 presents independent-samples t-test for VHGT level 1. It captured the number , minimum value, maximum value, means, standard deviations, degree of freedom, the t-statistic and significant value.

Table 14: Descriptive Statistics and Independent Samples t-test for Female and Male on Achievement Scores in VHGT Level 1 among the PSTs.

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	0	5	3.6	.85	238	.488	.63
Male	120	2	5	3.6	.73			

The results in Table 14 show that there was no statistically significant difference in mean scores between the female (*M = 3.6, SD =.85*) and male (*M = 3.6, SD = .73)* with (t=(238) = .488, p = .63 > .05). This shows that at level 1 majority of the female

PSTs individual scores fell within the range of (2.8% - 4.5%), while majority of the male scores were spread around the mean within the range of (2.9%- 4.3%).

Table 15 present the proportion of correct and wrong answers with percentage for VHGT level 2 of PSTs by gender. The discussion will be done by presenting the number with percentages of female and male PSTs who correctly or wrongly answered questions 6, 7, 8, 9, and 10 respectively.

Table 15: Gender comparison of number of correct and wrong answers level 2.

	Female		Male	
Question	Number of Correct answers with Percentages	Number of wrong answers with Percentages	Number of Correct answers with Percentages	Number of wrong answers with Percentages
6	95 (79.2%)	25 (20.8%)	57 (47.5%)	63 (52.5%)
7	100 (83.3%)	20 (16.7%)	90 (75%)	30 (25%)
8	43 (35.8%)	77 (64.2%)	93 (77.5%)	27 (22.5%)
9	112 (93.3%)	8 (6.7%)	102 (85%)	18 (15%)
10	22 (18.3%)	98 (81.7%)	56 (46.7%)	64 (53.3%)
Total	**372 (62%)**	**228 (38%)**	**398 (66.33%)**	**202 (33.66%)**

For level 2 female correct answer proportion was 62% and wrong answer proportion was 38% as shown in Table 15. Similarly, their male counterparts correct answer proportion was 66.33% while the wrong answer was 33.67%. The female PSTs did very well on items 6, 7 and 9. From the sample of 120 PST, 95 (79.2%) , 100 (83.3%) and 112 (93.3%) respectively answered items 6, 7 and 9 correctly. The male PSTs also correctly answered 57 (47.5%), 90 (75%), 93 (77.5%), 102 (85%) and 56 (46.7%) for items 6, 7, 8, 9 and 10 respectively. The female PSTs performance was not good because it recorded 43 (35.8%) and 22 (18.3%) respectively for items 8 and 10 which are below 50% correct answers to those particular test items. Similar, results by the male PSTs showed that items 6 and 10 were difficult for them because those items correct answers were below 50%. Question 9 was the most easiers for both gender while question 10 was the difficult for both gender too. Some PSTs truly understood properties of isosceles triangle which was question 9. Also, both gender had poor understanding of properties of kite and rhombus concepts which were question 10. This clearly shows that some PST lacked knowledge of properties of kite and rhombus. In level 2, a total of 228 wrong answers came from the female PSTs and 202 wrong answers came from the males. This suggest that some PSTs have problems in understanding properties of squares, rhombus, isosceles triangles, kite with their diagonals, and sides. Tutors of Colleges of Education need to do more work on properties of kite, squares, rhombus, and isosceles triangles with several spartial orientations of the shapes. For instance, tutors should use big squares and small squares to demonstrate that whether the shape is big or small the properties of squares remain the same even in different spartial orientations or positions. At this level tutors should let PSTs recognize that properties of shapes are independent of one another.

Sub research hypothesis 1.2. Ho: There is no significant difference between female and male PSTs' VHGT achievement scores in level 2

Table 16 presents the indepedent t-test analysis for VHGT level 2.

Table 16: Descriptive Statistics and Independent Samples t-test for Female and Male on Achievement Scores in VHGT Level 2 among the PSTs.

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	1	5	3.1	0.88	238	-1.025	.306
Male	120	1	5	3.2	1.00			

From Table 16, it has shown that the average score obtained by the males was higher than that of the females. The t-test result indicates that the male (Mean=3.2; SD = 1.00) and female (Mean=3.1; SD = 0.88) with t calculated = -1.025 and p-value = .306 > .05, so we upheld the null hypothesis. Thus, there is no significant difference between female and male PSTs geometrical achievement scores eventhough a mean difference of 0.12 was in favour of the male PSTs. This suggest that at level 2 majority of the female scores were spread around (2.2% - 3.9%) while majority of the male scores fell within the (2.2% - 4.2%).

Table 17 presents the proportion of questions 11, 12, 13, 14, and 15 correct and wrong answers results for VHGT level 3 of PSTs by gender.

Table 17: Gender comparison of number of correct and wrong answers percentages for level 3

	Female		Male	
Question	Number of Correct answers with Percentages	Number of wrong answers with Percentages	Number of Correct answers with Percentages	Number of wrong answers with Percentages
11	17 (14.2%)	103 (85.5%)	78 (65%)	42 (35%)
12	27 (22.5%)	93 (77.5%)	85 (70.8%)	35 (29.2%)
13	91 (75.8%)	29 (24.2%)	88 (73.3%),	32 (26.7%)
14	14 (11.7%)	106 (88.3%)	44 (36.7%)	76 (63.3%)
15	76 (63.3%)	44 (36.7%)	64 (53.3%)	56 (46.7%)
Total	**225 (37.5%)**	**375 (62.5%)**	**359 (59.83%)**	**241 (40.16%)**

Subtest 3 questions is about learners knowing the interrelationship between different types of figures. The PSTs performance for that level was not good. The female PSTs only perfomed well in items 13 and 15 because the correct answer proportion was above 50% for those items. The female detailed correct answer proportions for that level were as follows; 17 (14.2%), 27 (22.5%), 91 (75.8%) , 14 (11.7%) and 76

(63.3%) were for items 11, 12, 13, 14 and 15 respectively as in Table 17. Likewise, that of the male PSTs were 78 (65%) for item 11, 85 (70.8%) for item 12, 88 (73.3%) for item 13, 44 (36.7%) for item 14 and 64 (53.3%) for item number 15. The level 3 female correct answer proportion was 37.5% and wrong answer proportion was 62.5%, similarly their male counterparts correct answer proportion was 59.8% while the wrong answers proportion summed to 40.2%. The most wrong answers captured by both gender was on question 14, where 88.3% for female and 63.3% for male could not answer it correctly. Question 14 was to to find out PSTs knowledge on classes of shapes rather than individual shapes. This suggest that some PSTs could not develop relationship between properties of rectangles, squares, and parallelogram. They could not also see hierarchy of properties and shapes. Teachers should emphasis that, geometry shapes go with their properties after identifying properties of individual shapes. This clearly shows that some PSTs lack knowledge of class of inclusion of shapes where PSTs are suppose to identify all squares as rectangles.

Sub research hypothesis 1.3: Ho: There is no significant difference between female and male PSTs' VHGT achievement scores in level 3

Table 18 displays the independent sample t-test results for VHGT level 3 by gender.

Table 18: Descriptive Statistics and Independent Samples t-test for Female and Male on Achievement Scores in VHGT Level 3 among the PSTs.

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	0	4	2.0	.89			
Male	120	0	5	2.7	.99	238	-6.117	.000

The results in Table 18 show that there was statistically significant difference in mean scores between the female group (*M* = 2.0*, SD* = .89) and male group (*M* = 2.8*, SD* = .99) conditions; t (238) = -6.117*, p* = .000> *.05*. These results suggest that male PSTs performed better than their female counterparts at level 3 with a mean difference of 0.7. This indicates at level 3, majority of the female scores were spread around the range of (1.1% - 2.9%) while majority of the male scores fell within the range (1.7% - 3.7%).

Table 19 present questions 16, 17, 18, 19, and 20 correct and wrong answers proportion with percentage for VHGT level 4 of PSTs by gender.

Table 19: Gender comparison of number of correct and wrong answers for level 4.

	Female		Male	
Question	Number of Correct answers with Percentages	Number of wrong answers with Percentages	Number of Correct answers with Percentages	Number of wrong answers with Percentages
16	21 (17.5%)	99 (82.5%)	16 (22.5%)	104 (77.5%)
17	16 (13.3%)	104 (86.7%)	29 (24.2%)	91 (75.8%)
18	18 (10.8%)	102 (89.2%)	18 (15%)	102 (85%)
19	5 (4.2%)	115 (95.8%)	11 (9.2%)	109 (90.8%)
20	31 (25.8%)	89 (74.2%)	34 (28.3%)	86 (71.7%)
Total	**91 (15.17%)**	**509 (84.83%)**	**108 (18%)**	**492 (82%)**

As can be seen in Table 19, the level 4 female correct answers proportion was 15.2% and wrong answers with 84.8% whereas 18% correct answers and 82% wrong answers for their male counterparts. Further analysis has shown that female answers for items 16-20 were poorly answered because the following percentages is confirmation of the fact, 21 (17.5%), 16 (13.3%), 18 (10.8%), 5 (4.2%), and 31 (25.8%) for items 16, 17, 18, 19 and 20 respectively. Similarly, the male percentages are 16 (22.5%) for item 16, 29 (24.2%) for item 17, 18 (15%) question 18, 11(9.2%) for item 19, and 34 (28.3%) for question 20. The male PSTs correct answers in level 4 is no different from their female counterparts because both gender correct answers proportions were lessthan 50% in all the items. Item 19 was the toughers question for both gender because the wrong answers are 115 (95.8%) and 109 (90.8%) for female and male respectively. The said item was about logical deduction. For this level, a total of 84.83% wrong answers came from the female PSTs and 82% wrong answers came from their male counterparts. This means that PSTs could not work questions with abstract statements about geometric properties and make conclusions based more on logic than intuition. They could not do simple proof either. This could be as a results of some teachers insufficient knowledge of proof or skipping topics that involves abstraction and proof.

Sub research hypothesis 1.4: Ho: There is no significant difference between female and male PSTs' VHGT achievement scores in level 4

Table 20 captures the independent sample t-test results for VHGT level 4

Table 20: Descriptive Statistics and Independent Samples T-Test for Female and Male on Achievement Scores in VHGT Level 4 among the PSTs.

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	0	4	0.8	.86	238	-2.328	.021
Male	120	0	5	1.0	.92			

The results of Independent t-test in Table 20 showed a statistically significant difference in level 4 scores (t=(238) = -2.328, p = .021 < .05) between female and male PSTs. The male PSTs recorded a higher mean performance (M = 1.0 , SD = .92) better than the female with (M = 0.8, SD = .86). This results means that at level 4, majority of the female PSTs scores were spread around the mean of (-0.1% - 1.7%) while majority of the male PSTs scores fell within the range (0.1% - 1.9%). The difference between their means was 0.2 in favor of the male PSTs. This finding indicates that, male PSTs performance is better than their female counterparts in level 4.

Table 21 Presentsthe proportion of questions 21, 22, 23, 24, and 25 correct and wrong answers for VHGT level 5 of PSTs by gender.

Table 21: Gender comparison of number of correct and wrong answers level 5

	Female		Male	
Question	Number of Correct answers with Percentages	Number of wrong answers with Percentages	Number of Correct answers with Percentages	Number of wrong answers with Percentages
21	30 (25%)	90 (75%)	25 (21%)	95 (79%)
22	14 (11.7%)	106 (88.3%)	15 (12.5%)	105 (87.5%)
23	19 (15.8%)	101 (84.2%)	21 (17.5%)	99 (82.5%)
24	11 (9.2%)	109 (90.8%)	12 (10%)	108 (90%)
25	9 (7.5%)	111 (92.5%)	21 (17.5%)	99 (82.5%)
Total	**83 (13.83%)**	**517 (86.17%)**	**94 (15.67%)**	**506 (84.33%)**

Table 21 indicates that the female correct answers for items 21, 22, 23, 24 and 25 are 30 (25%), 14 (11.7%), 19 (15.8%), 11 (9.2%), and 9 (7.5%) respectively. Similarly, items 21, 22, 23, 24, and 25 were correctly answered by the male in this order 25 (21%), 15 (12.5%), 21 (17.5%), 12 (10%) and 21 (17.5%) respectively. The best performance was question 21 and worse performance was question 24 for the male while that of the female best performance was 21 and worse being item 25. The female and male correct answer proportion were 13.83% and 15.66% respectively for level 5 of the VHGT. In level 5, a total of 86.17% wrong answers came from the female PSTs and 84.33% wrong answers came from the male PSTs. Teachers should be taking students through deductive axiomatic systems for geometry because majority of the PSTs could not cope with this level. The performance here is very poor because at least 75% of both gender provided a wrong answer at this level.

Sub research hypothesis 1.5: Ho: There is no significant difference between female and male PSTs' VHGT achievement scores in level 5

Table 22 presented the independent sample t-test results for VHGT level 5.

Table 22: Descriptive Statistics and Independent Samples T-Test for Female and Male on Achievement Scores in VHGT Level 5 among the PSTs

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	0	4	.7	.98	238	-.819	.414
Male	120	0	3	.8	.91			

There is no statiscally significant difference between the groups. However, there was a difference of 0.1 in favor of the male PSTs. In addition t calculated = -.819 and p-value= .414 > .05, so we upheld the null hypothesis. The t-test result indicates that the male (Mean=0.8; SD=0.91) did well in the VHGT than their female counterparts with (Mean=0.7; SD=0.98). This implies that at level 5 majority of the female PSTs scores were spread around the range (-0.3% - 1.7%), while majority of the male group scores fell within the range of (-0.1% - 1.7%).

Main research hypothesis: Ho: There is no significant difference between female and male PSTs' VHGT achievement scores.

Table 23 presents the independent t-test results for all the VHGT levels computed together.

Table 23: Descriptive Statistics and Independent Samples T-Test for Female and Male on Achievement Scores in all VHGT Levels among the PSTs.

Group	N	Minimum	Maximum	Mean	Std. Dev.	Df	T	Significance
Female	120	4	16	10.3	2.33	238	-3.987	.000
Male	120	6	18	11.4	2.27			

The independent sample t-test results indicate that there is statistically significant difference in VGHT for all the levels when combined together between the male and female PSTs. The mean score of the male is slightly better than the female (11.4>10.3). The mean difference was 1.1 in favour of male PSTs. The standard deviations for the female and male are recorded as 2.33 and 2.27 respectively. Table 23 further indicates that, (t (238) = -3.987, p= .000 < .05). Hence the null hypothesis is rejected. This implies that in all the levels, majority of the female PSTs scores fell within the range of (8.0% - 12.6%) while majority of the male group scores fell within the range of (9.1% - 13.7%).

4.5 Research hypotheses 2: There is no significant difference between female and male PSTs attitude towards geometry

The researcher analyzed the following attitude towards geometry by testing the following sub null hypotheses.

Sub research hypothesis 2.1 : Ho: There is no significant difference between female and male PSTs usefulness of studying geometry.

Table 24 presents the independent t-test results of the PSTs attitude towards geometry under the usefulness of learning geometry construct by gender. The data for this analysis was from the 5-point Likert scale responses on usefulness of learning geometry from the PSTs.

Table 24: Descriptive Statistics and Independent Samples t-test for Female and Male on usefulness of studying geometry.

Construct	Group	N	Mean	Sd	df	T	Sig	Decision
	Female	119	3.5	.79	237	-4.136	.000	Differences
Usefulness	Male	120	3.9	.72				

Table 24 indicates that there is statistically significant difference between the groups on their perceived usefulness of studying geometry, because t (237) = -4.136 and p-value= .000 < .05, so we reject the null hypothesis. The t-test result indicates that the male (Mean=3.9; SD=0.72) thinks positively towards usefulness of studying geometry than their female counterparts with (Mean=3.5; SD=0.79). This implies that majority of the female PSTs responses from the 5-point Likert scale were within the range (2.7– 4.3) meaning between disagree and agree, while majority of the male group responses from the 5-point Likert scale fell within the range of (3.2 – 4.6) meaning between neutral and agree. Below is the analysis of the second sub hypothsis 2.2.

Sub research hypothesis 2.2: Ho: There is no statistically significant difference between female and male PSTs responses to confidence in learning geometry.

Table 25 presents t-test analysis of PSTs attitude towards geometry under the confidence of learning geometry construct.

Table 25: Descriptive Statistics and Independent Samples T-Test for Female and Male on their confidence in learning geometry.

Construct	Group	N	Mean	St. Dev	Df	T	Sig	Decision
	Female	120	3.2	.67	238	-3.069	.002	Difference
Confidence	Male	120	3.5	.58				

From Table 25, the results of the independent sample t-test shows that there is statistical significance difference between female and male PSTs in favour of the male. The female PSTs had (M=3.2, SD=0.67) and male (M=3.5, SD= 0. 58) when (t (238) = -3.069, p= .002 < .05). The result indicates that, the male PSTs have a lot of confidence in learning geometry than their female counterparts. This also implies that majority of the female PSTs responses from the 5-point Likert scale fell within the range (2.5 – 3.9) meaning between disagree and neutral, while majority of the male group responses from the 5-point Likert scale fell within the range of (2.9 – 4.1) meaning between disagree and agree.

Sub research hypothesis 2.3: Ho: There is no statistically significant difference between female and male PSTs responses to enjoyment of learning geometry.

Table 26 presents the descriptive statistics of PSTs attitude towards geometry under the enjoyment of learning geometry construct.

Table 26: Descriptive Statistics and Independent Samples T-Test for Female and Male on enjoyment of learning geometry.

Construct	Group	N	Mean	Sd	Df	T	Sig	Decision
	Female	120	3.2	.67	237	-3.105	.002	Differences
Enjoyment	Male	119	3.5	.58				

Table 26 depicts the independent sample t-test of both female and male PSTs on their responses to enjoymentof learning geometry. From Table 26, there is statistically significant difference between the groups on their perceived responses to enjoyment of learning geometry, because t (237) =-3.105 and p-value= .002 < .05 with male (Mean = 3.5; SD = .58). It means the male PSTs enjoys learning geometry than their female counterparts with (Mean=3.2 ; SD= .67). This implies that majority of the female PSTs responses from the 5-point Likert scale were within the range (2.5 – 3.9) meaning between disagree and neutral, while majority of the male group responsesfrom the 5-point Likert scale were also within the range of (2.9 – 4.1) meaning between disagree and agree. The null hypothesis was rejected based on the analysis.

Main Research hypothesis 2: Ho: There is no statistically significant difference between female and male PSTs responses on attitude towards geometry with usefulness, confidence and enjoyment of geometry all combined.

Table 27 presents the descriptive statistics of PSTs attitude towards geometry. The main hypothsis being tested..

Table 27: Descriptive Statistics and Independent Samples T-Test for Female and Male on on attitude towards geometry.

Construct	Group	N	Mean	Sd	df	T	Sig	Decision
Attitude	Female	120	3.3	.57	238	-4.443	.000	Differences
	Male	120	3.6	.50				

Table 27 displays the independent sample t-test of both female and male PSTs on their responses from the 5-point Likert scale on attitude towards studying geometry. From the results, it has revealed that there is statiscally significant difference between the female and male PSTs on their attitude towards studying geometry, because the independent sample t-test has reported the following t (238) = - 4.443 and p-value= .000 < .05, so we reject the null hypothesis that there is no significant difference between female and male PSTs attitude towards geometry. The t-test result indicates that the male (Mean=3.6; SD=0.50) has shown more positive attitude towards studying geometry than their female counterparts with (Mean=3.3; SD=0.57). This suggests that majority of the female PSTs attitude towards geometry responses from the 5-point Likert scale fell within the range (2.7– 3.9) meaning between disagree and neutral, while majority of the male group attitude towards geometry responses from the 5-point Likert scale fell within the range of (3.1 - 4.1) meaning between neutral and agree. The next paragraph sort to figure out whether there is significant correlation and relationship between PSTs attitude towards geometry and their Van Hiele test achievements.

4.6 Research Hypothesis 3: There is no relationship between PSTs' VHGT achievement scores and their attitude towards geometry

Table 28 presents the correlation between PSTs attitude and VHGT achievements score. From Table 28 a decision of whether there is relationship between PSTs‟ VHGT achievement scores and their attitude towards geometry was made based on the Pearson correlation coefficients and the significant value. The null hypothesis being tested states that, there is no significant relationship between PSTs‟ VHGT achievement scores and their attitude towards geometry.

Table 28: Bivariate Correlation between PSTs Attitude and VHGT achievement scores

Statistics	Value
Pearson Correlation	.063
Sig. (2-tailed)	.334
N	240

As displayed in Table 28, the test of hypothesis at 0.05 significance level found a weak correlation between the PSTs attitude towards geometry and achievements. The correlation is also not significant at (r (240) = .063, p= .334 > .05). Hence, the null hypothesis is upheld implying there is no statistically significant relationship between PSTs‟ VHGT achievement scores and their attitude towards geometry. The analysis is suggesting that PSTs achievementsin geometry does not depend on their attitude towards geometry meaning there could be other factors contributing to this, rather than just the attitude of the PSTs. The teachers methods of teaching and general rapport between the teacher and the PSTs might also be a factor. The scatter plot of the PSTs attitude towards geometry and VHGT scores is captured in Figure 4.1 showing the very weak relationship.

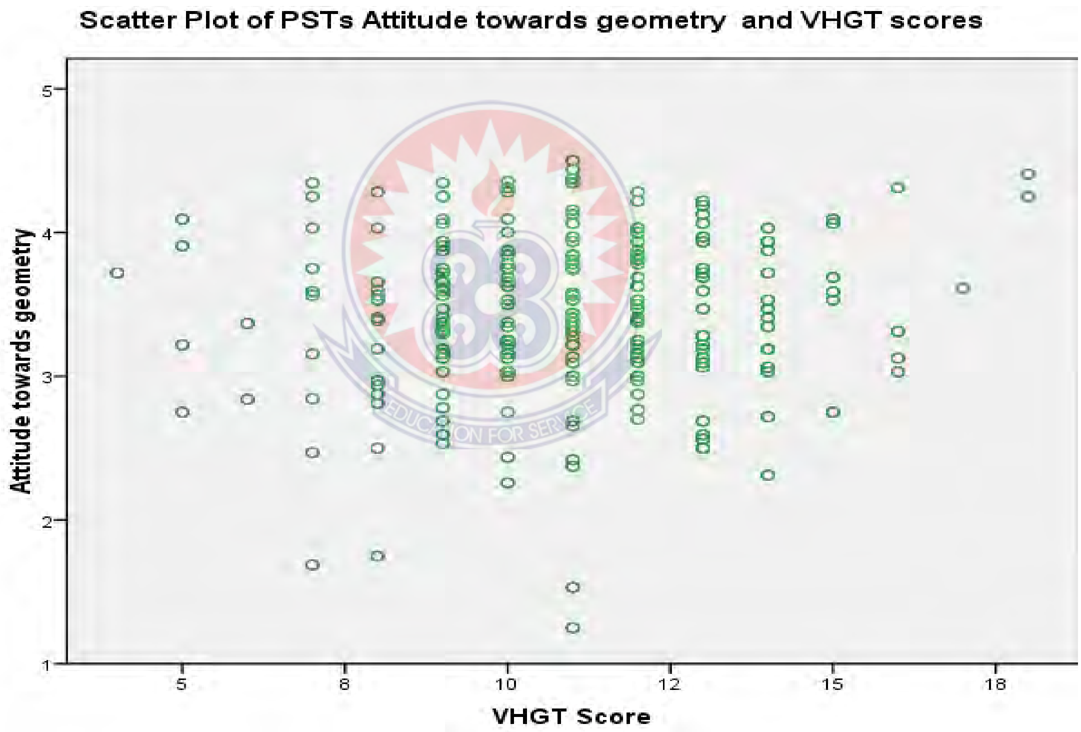

Figure 4.1: Attitude towards geometry and VHGT scores scatter plot

4.7 Discussion of Results

The purpose of the study was to investigate gender differences in pre-service teachers" Van Hiele"s geometric reasoning levels and their attitude towards geometry under the following variables (usefulness of learning geometry, confidence of learning geometry and enjoyment of learning geometry) of Northern Region Colleges of Education. Also, the study was to investigate whether there is relationship between PSTs" VHGT achievement scores and their attitude towards geometry. The essence is to figure out whether the PSTs actually possess the needed content knowledge and attitude to be able to teach their Junior High Schools students, since they are specifically trained to handle all Mathematics topics.

Research question one sort to establish the female and male PSTs" geometric reasoning levels. Twenty-eight (28) of the female PSTs were found to be reasoning between levels 0 and 1 which is similar to Armah et al. (2017) , Asemani et al.(2017), Salifu (2018a), and Salifu (2018b) where they found that some students were at those levels in their respective studies. This implies that those PSTs at level 0 were not able to sort and classify shapes e. g. squares based on their appearance whereas those at level 1 were able to sort and classify shapes. In order to improve students visualization, concepts teachers should present geometric concepts lessons with a lot of shapes like squares, triangles, rectangles and parallelograms in different spartial orientation. Teachers should tilt the squares, rectangles, triangles and parallelograms and find out from students whether those shapes still possess the same properties as those that have not been tilted. Students should also do a lot of activities like sorting and classifying shapes based on their appearance to aquire the geometric concepts at this level fast.

Majority (67) of the female PSTs were found at level 2. This means that they are able to recognize the properties of the shapes and know that the properties are independent of one another at that level. Since some PSTs still have problems with properties of figures, teachers should deliver geometric lessons by emphasing on diagonals and angles of squares, rhombus, isosceles triangles and kite. For instance tutors should emhasised that no matter the size of shape the properties are the same. Also, 25 PSTs were at level 3 implying that they were able to develop relationship between properties. They could also notice that shapes go together with their properties. At this level, the PSTs also noticed the hierarchy of properties and shapes are important. No female PST got to level 4 meaning those female PSTs could not find relationship among properties of geometric objects and could not work with abstract statements about geometric properties. Also they could not make conclusions based on logic than intuition. Finally, no female PST attained level 5. , This study tallies with Salifu (2018a) and Salifu et al. (2018) where they found no PSTs in level 5 in their respective studies. This suggest that PSTs could not show understanding in the axiomatic systems themselves and not just the deductions within a system. This is an indication that majority of the female PSTs were below their prospective pupils level hence teaching geometry at the Junior High School will be a problem. This also implies that majority of the female PSTs were not reasoning as tertiary students.

The male PSTs who were not reasoning at their future prospective pupils level were few and majority (66) attained levels 3. Few male PSTs were found at level 4. Only 1 male PST attained level 5 meaning he/she showed interest in the axiomatic systems and not just the deductions within a system. This result agree with the findings of Armah et al. (2017), Erdogan and Durmus (2009), Halat (2008), Halat and Sahin, (2008), Salifu (2018a), Salifu et al. (2018) and Salifu (2018b), who had similar results, where very few students attained levels 4 and 5.

The cumulative frequency comparison of both female and male PSTs achievement in VHGT has revealed that 82 out of 120 female PSTs and 66 out of 120 male PSTs scored marks below the half mark of 12. This current findings tallies with Armah et al.(2017), Armah et al.(2018), Asemani et al. (2017), Salifu (2018), findings where majority of the students attained marks below 12. However, only 19 from the 120 female PSTs scored exactly the half mark of 12 while 20 of their male counterparts achieved that mark. For those who scored above the half mark, 19 female PSTs achieved that while 34 males also achieved that. The result support the findings of studies conducted by Armah et al.(2017), Armah et al.(2018), Asemani et al. (2017), Baffour and Mereku (2010), Salifu (2018), where very few Mathematics PSTs attained marks above 12. This is an indication that female PSTs lacked behind their male counterparts in achievements. This performance of the PST in the VHGT was found to be very weak.

The results further found that there was no statistically significant difference between female and male PSTs achievements in level 1 (Visualization), level 2 (Analysis) and level 5 (Rigor). This result is related to the findings by the following researchers (Arhim & Offoe, 2015; Halat, 2008; Kwame et al., 2015; Karapınar & Alp İlhan, 2018; Mbacho & Changeiywo, 2013; Michelli, 2013; Salifu, 2018; Tetteh et al., 2018) who have all found no statistical differences in their studies on gender differences in mathematics. Also, in this study levels 3 and 4 yielded statistically significant difference between female and male PSTs achievements, which favoured the male PSTs. This study also corroborates with those of (Fennema (2005), Gavor (2014), Issahaq (2018), Moreno and Mayer (2009) and Olmez and Ozel (2012) who have all found statistical differences in their respective studies on gender differences in mathematics in favor of male students.

In conclusion the combined analysis from levels 1 to 5 has indicated that there is statistically significant difference in VGHT for all the levels between the male and female PSTs which favoured the male PSTs. This results is not similar to Salifu (2018) and Halat and Sahin (2008) where they found no significant difference between female and male PSTs Van Hiele geometric reasoning levels. This study is similar to studies by Fennema (2005), Issahaq (2018), and Moreno and Mayer (2009) where they found gender differences in their respective studies. This study results also differ from those of Bhowmik and Banerjee (2015), Larbi and Okyere (2014) where they found no significant differences between boys and girls performance in mathematics.

From the qualitative analysis majority (82.5%) of the female PSTs indicated that geometry is useful in real life. Most of them said it is useful in solving everyday problem. The solving of everyday problems enables students to develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof which supports Armah et al. (2017) findings. Also, majority of the PSTs said geometry will be needed in their future work which also corroborates with studies (Armah et al., 2018; Russell, 2014; Sunzuma et al., 2013) where they found that geometry is used daily by architects, engineers, physicists, land surveyors and many more professions. However, some of them said it has no link to everyday problems which differs from the findings of Van de Walle (2001) who found that geometry is linked to structure of the solar system art, architecture, cars, machines, geometric explorations, building a fence, designing a house and planning a garden.

Also, almost half (47.5%) of the total number of the female PSTs have acknowledge that they have confidence in learning geometry. This is direct opposite to the assertion or findings of Cann (2009) study where Wales‟s girls lacked confidence in mathematics. It is also not similar to Kyei et al. (2011) which found that girls‟ lack of self-confidence was a causal factor of the difference in the female performances. Confidence is very significant in learning mathematics because it enables students to be sure of themselves when solving non routine problems on their own especially studying new concepts. Confidence affects students‟ enjoyment, interest and involvement in mathematics. It is good to see almost half of the female showing confidences in geometry because it is perceived to be the most difficult mathematics course in Colleges of Education in Ghana. Some of the female PSTs opined that they always persevere to learn geometry because of the self confidence they have. This confidence can emanate from the classroom teachers who uses learner centred approach. Those students who concluded that geometry is difficult to understand might have not received confidence boosting from their teachers in the past.

Some (49.2%) of the female PSTs indicated that geometry is fun and interesting because their teachers might be using real and concrete objects in delivering the lessons or the use of mathematics software to make teaching of geometry fun and interesting. This assertion that, geometry is fun and interesting is similar to Kyeiet al. (2011) which found that students‟ interest in mathematics was inclined to personal interest and teaching methods of teachers. On the contrary some of the females PSTs said they do not enjoy geometry because it confuses them as well as boring. This could be attributed to the way the teachers present geometry lesson by making students to memorize formulas through rote learning. This suggest that if female PSTs are given equal opportunity by tutors in the classroom their confidence could be raised to make them enjoy geometry lessons.

For the male PSTs, majority (87.5%) of them said geometry was useful in solving everyday problems in real life,which is in line with Armah et al. (2017) findings where they argued that in solving everyday problem with geometry, PSTs develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof. This can be achieved in the classroom if teachers relate questions to real life situation by employing problems solving approaches. However, on the contrary some male PSTs indicated that geometry is not useful in real life. This could be attributed to teachers not relating classroom problems to the real world, they only resort to problems or questions in the text books which has no direct relation to real life situation.

Also, majority (73.3%) of male PSTs said they have confidence in learning geometry because geometry is easy to understand. However, some of the male PSTs disagree that geometry is easy by insisting that it is difficult. Their confidence can be boosted by teachers who uses innovative approaches such as problem solving or technology to arouse students interest. Also, the use of appropriate media and teaching approaches or methods which are grounded in learner centred pedagogies would make mathematics learning meaningful to the male PSTs and raise their confidence high.

Further analysis revealed that majority (68.3%) of the PSTs said they enjoy learning geometry because it improves their critical and logical thinking. This assertion tallies with Armah et al. (2017) research where they found that learning geometry improves skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof. On the contrary, some male PSTs said geometry is difficult to understand.

From the independent sample t-test there is statistically significant difference between the groups on their perceived usefulness of studying geometry. This study has revealed that PSTs attitude towards the usefulness of geometry was positive and that many of them believed that geometry is a valuable and necessary topic which can help them in their future teaching. This finding is similar to the findings of Young-Loveridge et al. (2006) which indicated that students see usefulness of mathematics as a major factor for their daily life and future career formation. This finding also tallies with Sunzuma et al. (2013) who found that students considered geometry to be useful. From this study, the mean difference recorded was in favour of males suggesting that male PSTs see geometry very useful than their female counterparts. Majority of the female PSTs responses on usefulness of learning geometry were between disagree and agree, while majority of the male group responses to usefulness of learning geometry were between neutral and agree.

From the analysis, significant differences exist between the female and male PSTs on their confidence in learning geometry. The records showed that the difference occurred was in favour of the Male PSTs. Majority of the female PSTs responses were between disagree and neutral, while majority of the male group responses were between disagree and agree. It revealed that male PSTs have more confidence in learning geometry than their female counterparts. This supports the findings of Asante (2010) and Kyei et al. (2011) who have all affirmed that girls lacked confidence, and perceived Mathematics as a male domain. This findings also corroborates with Bae et al. (2000) study that revealed females are less likely than males to think they were good at mathematics. Again to support this assertion is Cann (2009) who reported that Wales‟s girls were more likely than boys to report feelings of anxiety and a lack of confidence in mathematics. He went further to say that the main reason for female low participation in mathematics is due to lack of confidence as cited by Jones and Smart (1995).

Further analysis from the PSTs responses on whether they enjoy learning geometry also indicated a significant differences in favour of male PSTs. Majority of the female PSTs spread of responses were between disagree and neutral, while majority of the male group responses were also spread around disagree and agree.

In conclusion, when the overall t-test was conducted for all the constructs there was statistically significant difference among the groups in attitude towards geometry. So the main null hypothesis 2 was rejected and the researcher concluded that there is significant difference between female and male PSTs attitude toward geometry in favour of the male PSTs. This study is similar to Asante (2012), Michelli (2013), Sunzuma et al. (2013), Simegn and Asfaw(2018) and Tasdemir (2009) where they all found that male students have more positive attitude than their female counterparts. The findings of this study is direct opposite to the findings of Carroll and Gill (2011) where most female students had considerable positive attitudes towards mathematics than their male counterparts. Also, this findings does not agree with Nyala (2008) where he found that there was no gender difference between female and male students‟ attitudes towards mathematics at junior high school level. All the responses from the analysis has pointed to the fact that female geometry responses were between disagree and neutral, while majority of the male group attitude towards geometry responses were between neutral and agree.

Both the female and male PSTs had very weak positive correlation between their attitude towards geometry and achievements in all the VHGT levels. This finding totally corroborates with findings of Ma and Kishor (1997) where they reported that attitude towards Mathematics and achievement in Mathematics was positive and reliable but with a weak correlation. Also, there was no statistically significant relationship between both gender attitude and achievements scores in all the VHGT levels. This finding is similar to Soleymani and Rekabdar (2016) finding where they found that PSTs achievements in geometry do not depend on their attitude towards geometry. It also corroborates the findings of Mubeen et al. (2013) where attitude towards mathematics and achievement in mathematics did not go together. This study"s finding also differ from Tsao (2017) where it was found that the correlation between the attitude and achievement was statistically significant. This finding is opposite to the finding of Larbi and Okyere (2014) who documented that there was significant relationship between student attitude to using manipulatives and their mathematics achievement.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter provides the summary of the study and the major findings. It highlights the conclusion of the study and implications for practice. It further outlines some recommendations and avenues for future research.

5.1 Summary of Study

The purpose of the study was to investigate gender differences in pre-service teachers" Van Hiele"s geometric reasoning levels and their attitude towards geometry under the following variables (usefulness of learning geometry, confidence in learning of geometry and enjoyment of learning geometry) of Northern Region Colleges of Education. Also, the purpose was to investigate whether there is relationship between PSTs" VHGT achievement scores and their attitude towards geometry. The researcher essentially wants to figure out whether the PSTs actually possess the needed content knowledge and attitude to be able to teach their Junior High Schools students. In pursuance of this purpose, three research questions and three research hypothses were formulated to guide the study.

A cross-sectional survey design was used for the study. A mixed method approach was also adopted to collect the data, specifically the concurrent design where the qualitative and quantative data were collected together. The population and sample were drawn from E. P. Bimbilla, Bagabaga and Tamale Colleges of Education. The total sample was 240 PSTs making 120 each of female and male. The sampling procedures were convenient, stratified and simple random. The instruments used were 25-item VHGT and 32 item questionnaire on PSTs attitude towards geometry. The results of the different data sources: VHGT and questionnaires were used to answer the research questions and the hypothses.

5.2 Summary of Major Findings

The major findings of the study are summarized and presented in line with the research questions and research hypotheses.

1. The male PSTs attained higher reasoning levels than their female counterparts when the VHGT was conducted. Up to 12% of both female and male PSTs were however found to be operating in level 0 which is not encouraging.
2. It has also revealed that there was statistically significant difference between the male and female when the overall VHGT means was examined. The difference favoured the male PSTs who achieved higher mean.
3. From the questionnaire analysis, 82.5% and 87.5% PSTs indicated yes, to confirm that geometry is useful in real life respectively for female and male. Also, male PSTs yes responses on confidence in learning geometry was 73.3% while that of female was also 47.5%. The yes responses for female and male on enjoyment of geometry are 49.25% and 68.3% respectively.
4. Statistically significant difference was detected between the male and female in their responses to usefulness of learning geometry, confidence to learning geometry and enjoyment of learning geometry which all favour the male PSTs who showed positive attitude on usefulness of geometry. Finally, when the constructs of usefulness of geometry, confidence of learning geometry and enjoyment of geometry were computed together, it revealed that male had better or has shown more positive attitude than their female counterparts towards geometry. The analysis also indicated that there was statistically significant difference in attitude towards geometry in favour of male PSTs.

5. The study also revealed no statistically significant relationship between PSTs" VHGT achievement scores and their attitude towards geometry. Also, there was a very weak positive correlation between PSTs Attitude and VHGT achievement scores.

5.3 Implications of the Study

The study has shown that the VHGT has proven to be very effective strategy in identifying gender PSTs geometric reasoning levels, so that tutors can intervene by teaching those difficult concepts or levels using other approaches like Van Hiele model (Van Hiele phases of teaching) for teaching geometry. From the analysis, majority of female and some male PSTs may not be able to teach geometry effectively in the Junior High Schools. This might constitute a source for the failures for both gender in mathematics at the basic education level in Ghana. So there is the need for stakeholders in education to constantly update female and male tutors knowledge in geometry as well as in mathematics generally.

This study also indicated that some female and male PSTs do not see the usefulness of geometry outside the classroom which means that tutors of CoEs do not link geometry to real life situations when teaching geometry concepts. Hence, if these PSTs complete their programme they are likely going to be teaching geometry without relating to real life because they do not recognize the usefulness of geometry in life. Such PSTs might be skipping some geometry concepts. This might explain why students fail geometry when questions are presented in real life situation or in application format. The researcher will encourage female and male tutors to always give real life practical questions to solve in order to eliminate the perception that geometry is not useful after school. Also, some female and male PSTs do not have confidence in learning geometry which also contribute to their failure because they indicated it is difficult to understand and boring. These PSTs are likely going to discourage their students in learning mathematics at the basic school level which will results in failures in mathematics. Without the needed confidence in class by the female and male PSTs, not paying attention to tutors lesson will result in poor performance. Tutors should improve their classroom practices by building positive interpersonal relationship with both female and male PSTs and also the use of students centred approach in teaching geometry as suggested by Van Hiele phase based instruction. Also, tutors should relate mathematics concepts to everyday life situation. Tutors should also start counselling and motivating female and male students to improve their confidence levels in learning geometry. Some female and male PSTs stated that they do not enjoy learning geometry because it is difficult, confusing, boring and has so many rules and properties to understand. So the researcher wish to encourage tutors to adopt geometry software for teaching like geogebra and sketchpad to improve female and male students enjoyment of learning geometry.

5.4 Conclusion

Based on the findings made in this study, it can be concluded that:

1. The male PSTs performed better than their female counterparts in the reasoning exercise when VHGT was employed. Also, the male PSTs also did better than their female counterparts in the achievements in all the VHGT levels except the level 1.
2. The male PSTs think positively towards usefulness of studying geometry than their female counterparts. The male PSTs have more confidence than their female counterparts on confidence in learning geometry. More male PSTs

enjoy learning geometry than their female counterparts. The overall attitude towards geometry revealed that males had shown more positive attitude towards geometry than their female counterparts. The study also concludes that there was statistically significant difference in attitude towards geometry in favour of male PSTs.

3. The relationship between PSTs achievements scores and their attitude scores, has indicated a very weak positive relationship. Also, the correlation was not signicant at 0.05 level (2-tailed). It can be concluded that the issue of gender remains critical in the geometric achievements and attitude of those being trained to teach at the basic school in Ghana.

5.5 Recommendations

From the findings of this study, it is recommended that;

1. College Tutors and PSTs should consider gender issue seriously when teaching geometry (mathematics) because of the gap between female and male PSTs in reasoning levels and attitude in geometry.
2. The VHGT should be used to assess gender PSTs levels for intervention measure in geometry.
3. On the issue of the usefulness of geometry, tutors should present geometry concepts practically by relating it to real life situations.
4. Tutors should also develop PSTs confidence in learning geometry by constantly motivating and encouraging both sex to persevere to work more examples on their own.

5.6 Areas for Further Research

The educational implication of the findings of this study calls for further research involving the Van Hiele model in Ghana. The following are suggested for further research:

1. Similar studies should be conducted in Southern Ghana COEs.
2. Other geometry topics like 3- dimension should also be researched into.
3. Other attitude scales aside usefulness, confidence and enjoyment of geometry should be considered in future studies.

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APPENDIX A

Prof. Zalman Usiskin Letter and Consent Letter from Bagabaga College of Education

BAGABAGA COLLEGE OF EDUCATION

(MINISTRY OF EDUCATION)

Our Ref. No. GES/NR/TC/TT.95/8/2
Your Ref No.:

Tel: 071 23247
E-Mail: bcimi@yahoo.com

POST OFFICE BOX 35
EDUCATION RIDGE
TAMALE

7th February, 2019

MR ANASS SALIFU SEIDU
E.P. COLLEGE OF EDUCATION
BIMBILLA

Dear Anass Salifu,

APPROVAL TO CONDUCT RESEARCH IN BAGABAGA COLLEGE OF EDUCATION

Referenced your letter dated 5th February, 2019 in which you sought permission to carry out a study on our premises we wish to inform you that the College has no objection to that request.

Please note that the College will not be able to support you financially.

We wish you a successful study and do acknowledge where it is appropriate.

Sincerely,

Emmanuel Alhassan
(Vice Principal)

for: Principal

ANAS SALIFU 3/28/2018
Dear Sir, I am actually now going to conduct my study. I have just finished writing the

Zalman Usiskin
to me
3/29/2018 View details

Dear Mr. Salifu:

Thank you for this information.

We are pleased to give you permission to duplicate the van Hiele Geometry test for the study that you described in your e-mail. You need to have at the bottom of the first page of each copy of the test "Copyright © 1980 by the University of Chicago".

I have a question. Your sample is quite large. Are all these preservice teachers of mathematics at the secondary school level, or are many or most of your sample preservice teachers planning to teach in grades K-6?

Best wishes for a successful study.

Zalman Usiskin
Professor Emeritus of Education
Director, University of Chicago School Mathematics Project
The University of Chicago
127 Press Building
1427 East 60th Street
Chicago, IL 60637

APPENDIX B

Open ended questionnaire responses of female PSTs

FEMALE

S.No	Question	No.	Yes (%)	Most common reason (s) given for yes (%)	No (%)	Most common reason (s) given for No (%)	Blank
1	Is learning geometry useful in real life?	120	(82.5%)	1. It is useful in solving everyday problems (39.2%) 2. It is applicable to everyday life (13.3%) 3. To know and identify shape(5%) Other smaller reasons put together (42.5%)	(14.2%)	1. It has no link to everyday problems (10.9%) Other smaller reasons put together (89.1%)	3.3%
2	Do you have the needed confidence to learn geometry?	120	47.5%	1. I always perserve to learn geometry (20%) 2. It is practical subject (1.7%) 3. My fourite subject (1.7%) Other smaller reasons put together (76.6%)	(44.2%)	1. Difficult to understand geometry(14.2%) 2. I hate it (4.1%) 3. It is confusing and boring (4.1%) 4. Weak foundation (5.8%) Other smaller reasons put together (71.8%)	8.3%
3	Do you enjoy learning geometry?	120	49.2%	1. Motivated to solve geometry problem (10%) 2. it improves my critical and logical thinking (5.9%) 3. it is practical (2.5%) 4. It is fun and interesting (15%) Other smaller reasons put together (66.6%)	41.7%	1. Difficult to understand geometry(6.7%) 2. It is confusing and boring (14.2%) 3. It is difficult because of so many rules and properties (4.1%) Other smaller reasons put together (75%)	9.1%

Open ended questionnaire responses of male PSTs

MALE

S.No	Question	Number	Yes (%)	Most common reason (s) (%) given for yes	No (%)	Most common reason (s) (%) given for No	Blank
1	Is learning geometry useful in real life?	120	87.5%	1. it is useful in solving everyday problems (51.7 %) 2. it is applicable to everyday life (11.7 %) 3. promotes critical thinking (7.5 %) 4 it helps me to identify shapes and their properties (5 %) Other smaller reasons put together (24.1%)	7.5 %	1.It is not useful for me (4.2 %) 2. geometry is not applicable in life (1.6 %) Other smaller reasons put together (94.2%)	5 %
2	Do you have the needed confidence to learn geometry ?	120	73.3%	1. easy to understand geometry (13.3%) 2. I always perservere to learn geometry (12.5%) 3. Because am always motivated to solve geometry problem (5.8 %) 4. It is fun and interesting (4.2%) 5. It is Practical and based on concrete materials (3.3 %) Other smaller reasons put together (60.9%)	18.3%	1. difficult to understand geometry (13.3%) 2. It is confusing and boring (2.5%) Other smaller reasons put together (84.2%)	8.3 %
3	Do you enjoy learning geometry ?	120	68.3 %	1. it improves my critical and logical thinking (17.5%) 2. Easy to understand (12.5%) 3. It is fun and interesting (9.2 %) 4. Because am always motivated to solve geometry problem (7.5%). 5 It is Practical and based on concrete materials (5.8 %) Other smaller reasons put together (47.5%)	24.2%	1. Difficult to understand geometry (12.5%) 2. it is confusing and boring (10%) Other smaller reasons put together (77.5%)	7.5%

APPENDIX C

Female VHGT each level scores correlated against PSTs usefulness, confidenceand enjoyment of learning geometry.

Levels	Usefulness	Confidence	Enjoyment
LEVEL 1	r = 0.061	r = 0.022	r = 0.045
	p = 0.510	p = 0.812	p = 0.624
	n =119	n = 120	n = 120
LEVEL 2	r = 0.105	r = - 0.044	r = - 0.040
	p = 0.257	p = 0.636	p = 0.666
	n = 119	n = 120	n = 120
LEVEL 3	r = 0.199	r = 0.137	r = - 0.040
	p = 0.198	p = 0.136	p = 0.666
	n = 119	n = 120	n = 120
LEVEL 4	r = - 0.157	r = 0.111	r = 0.150
	p =0.088	p = 0.229	p = 0.103
	n =119	n = 120	n = 120
LEVEL 5	r = 0.074	r = - 0.048	r = - 0.002
	p =0.421	p = 0.601	p = 0.983
	n =119	n = 120	n = 120

Male VHGT each level scores correlated against PSTs usefulness, confidenceand enjoyment of learning geometry.

Levels	Usefulness	Confidence	Enjoyment
LEVEL 1	r = -0.034	r = - 0.003	r = - 0.079
	p = 0.714	p = 0.972	p = 0.393
	n = 120	n = 120	n = 120
LEVEL 2	r = - 0.060	r = 0.013	r = - 0.114
	p = 0.516	p = 0.885	p = 0.213
	n =120	n = 120	n =120
LEVEL 3	r = - 0.069	r =0.000	r = 0.039
	p = 0.451	p =0.998	p = 0.669
	n = 120	n = 120	n = 120
LEVEL 4	r = 0.150	r = -0.174	r = -0.098
	p =0.101	p =0.057	p = 0.285
	n =120	n = 120	n = 120
LEVEL 5	r = 0.051	r = -0.019	r = 0.123
	p =0.580	p = 0.835	p = 0.181
	n =120	n = 120	n =120

APPENDIX D

VAN HIELE GEOMETRY TEST

Dear Student,

I am an M. Phil Mathematics student and a tutor at E.P. College of Education, Bimbilla. I am conducting a research to enable me write my thesis. Please kindly answer all the questions. The answers are for educational purposes and are not meant for individual assessment. Your answers will be treated confidentially. Thank you for your cooperation.

Name of College……………………………………………………………………

Level……………………………………………………………..……………

Age……………………………………………………………………….…………

Native Region…………………………………………………………………

Gender……………………………………………………………………………

Programme of study at College……………………………………………………….

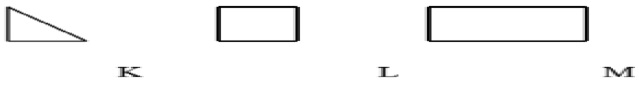
Date ……………………………………………………………………………………….

VAN HIELE GEOMETRY TEST and marking scheme

Mathematics Preservice Teachers

Answer all the questions. There are 25 multiple choice questions. Circle the right option using a pen. If you want to change an answer, just cross out the first answer. You will have 45 minutes to complete this test. Wait until the researcher says that you may begin.

1. Which of these are squares?

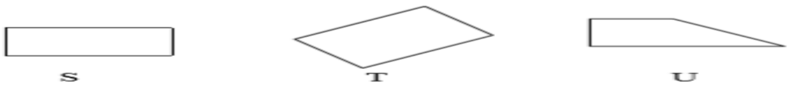


(A) K only **(B)** L only **(C)**
M only **(D)** L and M only
(E) All are squares

2. Which of these are triangles?

(A) None of these are triangles.
(B) V only **(C)** W only **(D)** W and X only **(E)** V and W only

3. Which of these are rectangles?

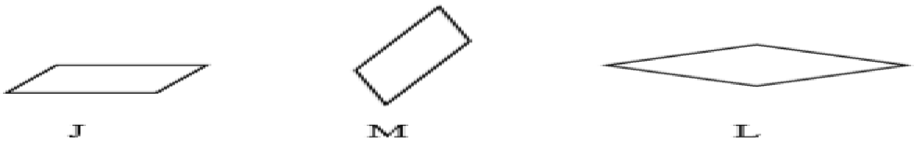


(A) S only **(B)** T only **(C)** S and T only **(D)** S and U only **(E)** All are rectangles.

4. Which of these are squares?

(A) G and I only.**(B).** G only **(C).** F and G only **(D).** All are squares **(E).** None of these are squares.

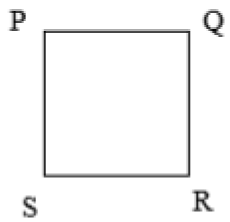
5. Which of these are parallelograms?



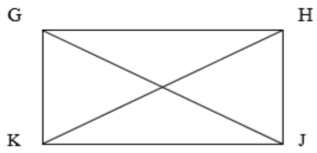
(A). J only **(B).** L only**(C).** J and M only **(D).** All are parallelograms. **(E).** None of these are parallelograms.

6. PQRS is a square.

Which relationship is true in all squares?
A. $\overline{PR}$ and $\overline{RS}$ have the same length.
B. $\overline{QS}$ and $\overline{PR}$ are perpendicular.
C. $\overline{PS}$ and $\overline{QR}$ are perpendicular.
D. $\overline{PS}$ and $\overline{QS}$ have the same length.
E. Angle Q is larger than angle R.



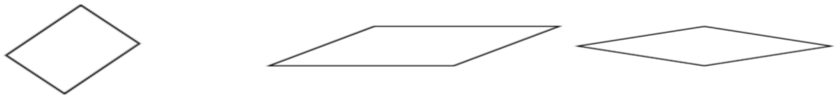
7. In the rectangle GHJK, $\overline{GJ}$ and $\overline{HK}$ are the diagonals.



Which of (A)-(D) is not true in every rectangle?

(A). There are four right angles. **(B).** There are four sides. **(C).** The diagonals have the same length. **(D).** The opposite sides have the same length. **(E).** All of (A)-(D) are true in every rectangle.

8. A rhombus is a 4-sided figure with all sides of the same length. Here are three examples.



Which of (A)-(D) is not true in every rhombus?

(A). The two diagonals have the same length. **(B).** Each diagonal bisects two angles of the rhombus. **(C).** The two diagonals are perpendicular. **(D).** The opposite angles have the same measure. **(E).** All of (A)-(D) are true in every rhombus.

9. An isosceles triangle is a triangle with two sides of equal length. Here are three examples.

Which of (A)-(D) is true in every isosceles triangle?

(A). The three sides must have the same length. **(B).** One side must have twice the length of another side. **(C).** There must be at least two angles with the same measure.

(D). The three angles must have the same measure. **(E).** None of (A)-(D) is true in every isosceles triangle.

10. Two circles with centers P and Q intersect at R and S to form a 4-sided figure PRQS. Here are two examples.

Which of (A)-(D) is not always true?

A. PRQS will have two pairs of sides of equal length.
B. PRQS will have at least two angles of equal measure.
C. The lines $\overline{PQ}$ and $\overline{RS}$ will be perpendicular.
D. Angles P and Q will have the same measure.
E. All of (A)-(D) are true.

11. Here are two statements. Statement 1: Figure F is a rectangle. Statement 2: Figure F is a triangle. Which is correct?

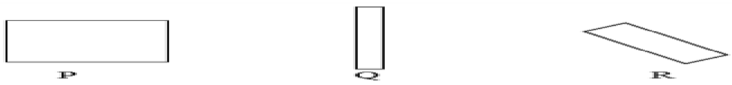
(A). If 1 is true, then 2 is true. **(B).** If 1 is false, then 2 is true. **(C).** 1 and 2 cannot both be true. **(D).** 1 and 2 cannot both be false. **(E).** None of (A)-(D) is correct.

12. Here are two statements. Statement S: ΔABC has three sides of the same length

Statement T: In ΔABC, ∠B and ∠C have the same measure. Which is correct?

(A). Statement S and T cannot both be true. **(B).** If S is true, then T is true. **(C).** If T is true, then S is true. **(D).** If S is false, then T is false. **(E).** None of (A)-(D) is correct.

13. Which of these can be called rectangles?



(A). All can. **(B).** Q only **(C).** R only **(D).** P and Q only **(E).** Q and R only

14. Which is true?

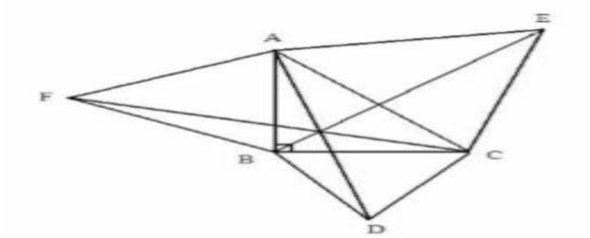
(A) All properties of rectangles are properties of all squares. **(B)** All properties of squares are properties of rectangles. **(C)** All properties of rectangles are properties of all parallelograms. **(D)** All properties of squares are properties of all parallelograms. **(E)** None of (A)-(D) is true.

15. What do all rectangles have that some parallelograms do not have?

(A) Opposite sides equal **(B)** Diagonals equal **(C)** Opposite sides parallel

(D) Opposite angles equal **(E)** None of (A)-(D)

16. Here is a right triangle ABC. Equilateral triangles ACE, ABF, and BCD have been constructed on the sides of ABC.



From this information, one can prove that AD, BE, and CF have a point in common. What would this proof tell you? **(A)** Only in this triangle drawn can we be sure that AD, BE and CF have a point in common. **(B)** In some but not all right triangles, AD, BE and CF have a point in common. **(C)** In any right triangle, AD, BE and CF have a point in common. **(D)** In any triangle, AD, BE and CF have a point in common. **(E)** In any equilateral triangle, AD, BE and CF have a point in common.

17. Here are three properties of a figure.

Property D: **It has diagonals of equal length**. Property S: **It is a square.** Property R: **It is a rectangle.** Which is true?

(A) D implies S which implies R.**(B)** D implies R which implies S. **(C)** S implies R which implies D.**(D)** R implies D which implies S. **(E)** R implies S which implies D.

18. Here are two statements.

I: **If a figure is a rectangle, then its diagonals bisect each other.**

II: **If the diagonals of a figure bisect each other, the figure is a rectangle.**

Which is correct?

(A) To prove I is true, it is enough to prove that II is true. **(B)** To prove II is true, it is enough to prove that I is true. **(C)** To prove II is true, it is enough to find one rectangle whose diagonal bisect each other. **(D)** To prove II is false, it is enough to find one non-rectangle whose diagonals bisect each other. **(E)** None of (A)-(D) is correct.

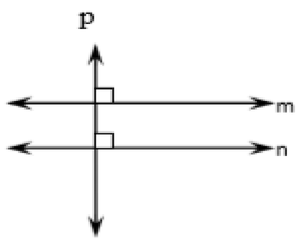
19. In geometry:

(A) Every term can be defined and every true statement can be proved true. (B) Every term can be defined but it is necessary to assume that certain statements are true. (C) Some terms must be left undefined but every true statement can be proved true. (D) Some terms must be left undefined and it is necessary to have some statements which are assumed true. (E) None of (A)-(D) is correct.

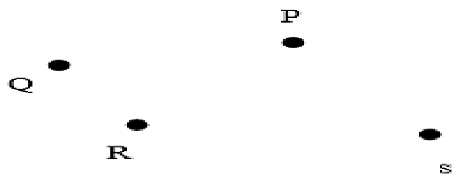
20. Examine these three sentences.

1. Two lines perpendicular to the same line are parallel.
2. A line that is perpendicular to one of two parallel lines is perpendicular to the other.
3. If two lines are equidistant, then they are parallel. In the figure below, it is given that lines **m** and **p** are perpendicular and lines **n** and p are perpendicular. Which of the above sentences could be the reason that line **m** is parallel to line **n**?

A. (1) only
B. (2) only
C. (3) only
D. Either (1) or (2)
E. Either (2) or (3)



21. In F-geometry, one that is different from the one you are used to, there are exactly four points and six lines. Every line contains exactly two points. If the points are P, Q, R and S, and the lines are {P,Q}, {P,R}, {P,S}, {Q,R}, {Q,S}, and {R,S}.



Here are how the words "intersect" and "parallel" are used in F-geometry. The lines {P,Q} and {P,R} intersect at P because {P,Q} and {P,R} have P in common. The lines {P,Q} and {R,S} are parallel because they have no points in common. From this information, which is correct?

(A){P,R} and {Q,S} intersect. **(B)** {P,R} and {Q,S} are parallel.
(C){Q,R} and {R,S} are parallel. **(D)**{P,S} and {Q,R} intersect. **(E)** None of (A)-(D) is correct.

22. To trisect an angle means to divide it into three parts of equal measure. In 1847, P.L. Wantzel proved that, in general, it is impossible to trisect angles using only a compass and an unmarked ruler. From his proof, what can you conclude?

(A) In general, it is impossible to bisect angles using only a compass and an unmarked ruler. **(B)** In general, it is impossible to trisect angles using only a compass and a marked ruler. **(C)** In general, it is impossible to trisect angles using any drawing instruments. **(D)** It is still possible that in the future someone may find a general way to trisect angles using only a compass and an unmarked ruler. **(E)** No one will ever be able to find a general method for trisecting angles using only a compass and an unmarked ruler.

23. There is a geometry invented by a mathematician J in which the following is true: The sum of the measures of the angles of a triangle is less than 180°. Which is correct?
(A) J made a mistake in measuring the angles of the triangle. (B) J made a mistake in logical reasoning.(C) J has a wrong idea of what is meant by "true". (D) J started with different assumptions than those in the usual geometry.(E) None of (A)-(D) is correct.

24. The geometry books define the word rectangle in different ways. Which is true? (A) One of the books has an error. (B) One of the definitions is wrong. There cannot be two different definitions for rectangle. (C) The rectangles in one of the books must have different properties from those in the other book. (D) The rectangles in one of the books must have the same properties as those in the other book. (E) The properties of rectangles in the two books might be different.

25. Suppose you have proved statements I and II. I: If p, then q. II: If s, then not q. Which statement follows from statements I and II?

(A) If p, then s. (B) If not p, then not q. (C) If p or q, then s. (D) If s, then not p.

(E) If not s, then p.

Good luck.

APPENDIX E

Questionnaire ID:

Questionnaire for Pre Service Teachers' Attitude towards Geometry

ATTITUDE TOWARDS GEOMETRY FORM

Dear Student,

I am a graduate student of the University of Education, Winneba. I am conducting a study on **pre-service teachers' geometric reasoning levels and attitude towards geometry.** This questionnaire seeks your views to help shape the teacher education mathematics curriculum to reflect the geometric needs for teaching. Please kindly respond to all the items. All your responses will be handled with all the confidentiality it deserves. The answers are for educational purposes and not for individual assessment.

SECTION A: PERSONAL DATA

Please tick (√), the appropriate response and/or provide your responses where necessary.

Name of College……………………………………………………………………………..

Level…………………………………………………………………..……………

Age……………………………………………………………………….…………

Programme of Study at College …………………………………………………..……

Date…………………………………………………………………………………

Native Region ……………………………………………..…………………………….

Gender ……………………………………………………………………..……...

SECTION B: ATTITUDE TO STUDYING GEOMETRY

In Table B1 are 10 statements on why you are studying geometry in school. On a scale of 1 – 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree), rate (by ticking in a box or cell) your agreement to the following statement about the usefulness in studying geometry in mathematics? (Please rate EVERY statement according to the scale)

B1 Usefulness of studying geometry

Statement about why studying geometry is useful	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I believe that I will need geometry for my future.					
2. Geometry has no relevance in my life.					
3. Geometry is not a practical subject to study					
4. I can see ways of using geometry concepts to solve every day problems.					
5. Geometry is not worthwhile to study.					
6. I often see geometry in everyday things.					
7. I will need a firm understanding of geometry in my future work.					
8. I do not expect to use geometry when I get out of school.					
9. I will not need geometry for my future.					
10. Knowing geometry will help me earn a living.					

In Table B2 are 12 statements on your confidence in learning geometry in school. On a scale of 1 – 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree), rate (by ticking in a box or cell) your agreement to the statements about your confidence in learning geometry in mathematics? (Please rate EVERY statement according to the scale)

B2 Confidence in learning geometry

Statement about your confidence in learning geometry	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
11. I am sure that I can learn geometry concepts.					
12. I often have trouble solving geometry problems.					
13. I am confident I can get good grades in geometry.					
14. When I cannot figure out a geometry problem, I feel as though I am lost and cannot find my way out.					
15. I lack confidence in my ability to solve geometry problems.					
16. I feel sure of myself when doing geometry problems.					
17. For some reason even though I study, geometry seems unusually hard for me.					
18. Geometry problems often scare me					
19. I am confident that if I work long enough on a geometry problem, I will be able to solve it.					
20. Geometry examinations usually seem difficult.					
21. I can usually make sense of geometry concepts.					
22. I have a lot of confidence when it comes to studying geometry.					

In Table B3 are 10 statements on your enjoyment in learning geometry in school. On a scale of 1 – 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree), rate (by ticking in a box or cell) your agreement to the statement on your enjoyment in learning geometry in mathematics? (Please rate EVERY statement according to the scale)

B3 Enjoyment of learning geometry

Statement about your enjoyment of learning geometry	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
23. Geometry problems are boring.					
24. When I leave class with a geometry question unanswered, I continue to think about it.					
25. When I start solving a geometry problem, I find it hard to stop working on it.					
26. Time drags during geometry class.					
27. Geometry is fun.					
28. I just try to get my homework done for geometry class in order to get a grade.					

29. Geometry is an interesting subject to study.					
30. Solving geometry problem is enjoyable.					
31. Working out geometry problems does not appeal to me.					
32. Geometry has many interesting topics to study.					

SECTION C: REASONS FOR STUDYING GEOMETRY

Instruction: kindly write legibly so that I can see. Feel free to write your opinion.

C1. **Is learning geometry useful** in real life? Yes ☐ or No ☐

Give your reasons……………………………………………………………………

C2. Do you have the needed **confidence to learn geometry?** Yes ☐ or No ☐
Give your reasons ……………………………………………

C3. Do you **enjoy learning geometry**? Yes ☐ or No ☐
Give your reasons……………………………………………

APPENDIX F
Marking Scheme for the VHGT

ITEM	ANSWER
1	B
2	D
3	C
4	B
5	D
6	B
7	E
8	A
9	C
10	D
11	C
12	B
13	A
14	A
15	B
16	C
17	C
18	D
19	D
20	A
21	B
22	E
23	D
24	E
25	D