EFFECTS OF VAN HIELE'S PHASE-BASED TEACHING STRATEGY AND GENDER ON PRE-SERVICE MATHEMATICS TEACHERS' GEOMETRY ACHIEVEMENT AND ATTITUDE TOWARDS GEOMETRY IN NIGER STATE, NIGERIA

HASSAN USMAN

UNIVERSITI SAINS MALAYSIA

2019

EFFECTS OF VAN HIELE'S PHASE-BASED TEACHING STRATEGY AND GENDER ON PRE-SERVICE MATHEMATICS TEACHERS' GEOMETRY ACHIEVEMENT AND ATTITUDE TOWARDS GEOMETRY IN NIGER STATE, NIGERIA

by

HASSAN USMAN

Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy

July 2019

DEDICATION

This work is dedicated to my father late Alhaji Usman Babayanna of blessed memory, my mother Hajiya Hadiza Usman and my beloved children Ibrahim, Salihu, Idris and Rahmat.

ACKNOWLEDGEMENT

My special gratitude goes to Almighty Allah for giving me good health and enough grace to undertake and complete this programme successfully.

My heartfelt gratitude goes straight to my main supervisor Dr. Wun Thiam Yew whose patience, scholarly advice, guidance and criticisms served as a light of knowledge and a gateway to the success of this work and a cause of a total positive change in my academic career. Indeed, I have been privileged to work with the best supervisor that any student could wish for; very easy going, hard working, intelligent and humble. I thank him for the pressure he mounted on me which enabled me to remain focused towards the completion of this research work. It was not easy moving on his expert terms and speed, still it was awesomely rewarding. I would also like to thank my co-supervisor AP Dr. Salmiza Saleh for her valuable guidance, support and encouragement in the completion of this thesis. Similarly, I acknowledge all authors whose materials were used in the course of carrying out this research.

My gratitude also goes to the Government of the Federal Republic of Nigeria and the management of Niger state College of Education Minna, Nigeria for finding me worthy to benefit from TETFund intervention for Academic Staff Training and Development. My profound gratitude goes to the teacher educators and pre-service teachers from the selected Colleges of Education who participated actively in the study.

I must acknowledge with deep sense of submission my Parents; late Alhaji Usman Babayanna and Mallama Hadiza usman for the parental tutelage, benefaction, financial and moral support I received from them at various stages of my educational pursuit. I also appreciate the sacrifice of my uncle Dr. Y.N Garba who never stopped

calling in order to encourage and to be abreast of my continual progress in faraway Malaysia. I owe a depth of gratitude to my twin brother Hussaini usman as well as my elder brother and sister Mal Musa Usman and Malama Amina Usman for their moral support and prayers during the course of my study.

My wife Hajara Majin deserves a special appreciation and love for her unflinching support, understanding and sacrifice. She indeed played the dual role of mother and father to my loving children Ibrahim, Salihu, Idris and Ramat while I studied. Indeed, words are not just enough to express my immense gratitude for her being there for me.

I cannot conclude this acknowledgement without thanking Dr. Caleb, Dr. Hadiza Mohammed, Baba Gana Kubo for their support at various stages. Finally, I am grateful to Ibrahim Kassim Badeggi who sacrificed both his material and immaterial resources irrespective of the deathly darkness and silence of the night, as he drove me disregarding all known oddities, for me to meet up with flight schedule on my first departure from Nigeria.

May Almighty Allah shower His blessings on you all (Amen).

TABLE OF CONTENTS

CHAPTER TWO - LITERATURE REVIEW

CHAPTER THREE - RESEARCH METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AAT	Algebra Achievement Test
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
AT	Achievement Test
ATGQ	Attitude Towards Geometry Questionnaire
ATGS	Attitude Toward Geometry Survey
ATMI	Attitudes Toward Mathematics Inventory
BFF	Beter Future Foudation
CDASSG	Cognitive Development and Achievement in Secondary School Geometry
CK	Content Knowledge
CTS	Conventional Teaching Strategy
ECCE	Early Childhood Education
EEN	Excellence and Education Network
FGN	Federal Government of Nigeria
FME	Federal Ministry of Education
FRN	Federal Republic of Nigeria
FSLC	First School Leaving Certificate
GAT	Geometric Achievement Test
GRT	Geometry Retention Test
GSP	Geometer's Sketchpad
HND	Higher National Diploma
JAMB	Joint Admission and Matriculation Board
JICA	Japan International Cooperation Agency

JSSC	Juniour Secondary School Certificate
JSSE	Juniour Secondary School Examination
MAN	Mathematical Association of Nigeria
MSPE	Master, Student, Partner, Extension
NABTE	National Board for Technical Examinations
NCCE	National Commission for Colleges of Education
NCE	Nigerian Certificate in Education
NECO	National Examination Council
NERC	National Education Research Council
NMC	Nigeria National Mathematics Curriculum
NTCM	The National Council of Teachers of Mathematics
NTE	National Teacher Examination
NTI	National Teachers Institute
NTI	National Teachers Institute
OND	Ordinary National Diploma
PBL	Problem Based Learning
PCK	Pedagogical Content Knowledge
SA	Strongly Agree
SCT	Style of Categorization Test
SD	Strongly Disagreed
SPSS	Statistical Package For Social Sciences
SRT	Statistics Retention Test
SSSC	Senior Secondary School Certificate
SSCE	Senior Secondary Certficate Examination
STAN	Science Teachers Association of Nigeria

STM	Science, Technology, and Mathematics
STME	Science, Technology and Mathematics Education
TAI	Team Assisted Individualized
TIMSS	Trends in International Mathematics and Science Study
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPE	Universal Primary Education
USA	United States of America
UTME	Unified Tertiary Matriculation Examination
VHPI	Van Hiele's phase-based instruction
VPBTS	Van Hiele's phase-based teaching strategy
WAEC	West African Examination council
WASCE	West Africa Senior Certificate Examination

KESAN STRATEGI PENGAJARAN BERASASKAN FASA VAN HIELE DAN GENDER TERHADAP PENCAPAIAN GEOMETRI DAN SIKAP TERHADAP GEOMETRI GURU MATEMATIK PRA-PERKHIDMATAN DI NEGERI NIGER, NIGERIA

ABSTRAK

Kajian ini menyelidiki kesan strategi pengajaran berasaskan fasa van Hiele dan gender terhadap pencapaian geometri dan sikap terhadap geometri guru matematik pra-perkhidmatan di negeri Niger, Nigeria. Enam persoalan kajian berserta hipotesis yang berkenaan telah dirangka untuk membimbing kajian ini. Reka bentuk kajian yang digunakan untuk kajian ini adalah reka bentuk faktor eksperimental kuasi dua kali dua (2x2). Seramai seratus empat puluh sembilan (149) orang guru matematik pra-perkhidmatan dari dua buah kolej pendidikan yang terletak di negeri Niger digunakan sebagai sampel kajian. Kolej sampel dipilih dengan menggunakan teknik pensampelan bertujuan. Kumpulan eksperimental didedahkan kepada strategi pengajaran berasaskan fasa van Hiele manakala kumpulan kawalan diajar topik yang sama dengan menggunakan strategi pengajaran konvensional. Ujian Pencapaian Geometri (GAT) yang mengandungi 30 item yang merangkumi topik-topik dalam bidang geometri digunakan untuk mengumpul data mengenai kedua-dua ujian pra-pencapaian dan pasca-pencapaian, sementara Soal Selidik Sikap terhadap Geometri (ATGQ) digunakan untuk mengumpul data mengenai sikap terhadap geometri. Pekali kebolehpercayaan 0.78 dan 0.73 masing-masing dicapai untuk Ujian Pencapaian Geometri dan Soal Selidik Sikap terhadap Geometri. Data tersebut dianalisis menerusi Analisis Varians (ANOVA) dua hala dan Analisis Kovarians (ANCOVA). Hipotesis kajian diuji pada tahap signifikan 0.05. Hasil kajian menunjukkan bahawa strategi

pengajaran berasaskan fasa van Hiele adalah lebih berkesan daripada strategi pengajaran konvensional dalam meningkatkan pencapaian dan sikap terhadap geometri guru matematik pra-perkhidmatan. Oleh sebab pendekatan ini (strategi pengajaran berasaskan fasa van Hiele) didapati berkesan dalam meningkatkan pencapaian dan sikap terhadap geometri guru matematik pra-perkhidmatan, strategi itu dicadangkan untuk kegunaan para pensyarah semasa mengajar para pelajar. Di samping itu, strategi ini dapat memberikan panduan kepada guru dalam pengajaran geometri, dan seterusnya mengurangkan cabaran yang dihadapi oleh guru dan juga guru matematik pra-perkhidmatan dalam pengajaran dan pembelajaran geometri.

EFFECTS OF VAN HIELE'S PHASE-BASED TEACHING STRATEGY AND GENDER ON PRE-SERVICE MATHEMATICS TEACHERS' GEOMETRY ACHIEVEMENT AND ATTITUDE TOWARDS GEOMETRY IN NIGER STATE, NIGERIA

ABSTRACT

The study investigated the effects of van Hiele's phase-based teaching strategy and gender on pre-service mathematics teachers' geometry achievement and attitude towards geometry in Niger State, Nigeria. Six research questions and corresponding hypotheses were formulated to guide the study. The research design adopted for the study was a two-by-two (2x2) quasi experimental factorial design. One hundred and forty-nine (149) pre-service mathematics teachers from two colleges of education situated in Niger state were used as research sample. The sample colleges were selected using a purposive sampling technique. The experimental group was exposed to van Hiele's phase-based teaching strategy while the control group was taught same topics with conventional teaching strategy. Geometry Achievement Test (GAT), is a 30 – item test covering topics in Geometry was used to collect data for both pre and post achievement test, while Attitude Towards Geometry Questionnaire (ATGQ) was used for collecting data on attitude towards geometry. A reliability coefficient of 0.78 and 0.73 was respectively obtained for Geometry Achievement Test and Attitude Towards Geometry questionnaire. The data were analyzed using two-way analysis of variance (ANOVA) and Analysis of Covariance (ANCOVA). The hypotheses were tested at 0.05 level of significance. The results of the study revealed that van Hiele's phase-based teaching strategy is more effective than conventional teaching strategy in improving pre-service mathematics teachers' achievement and attitude towards

geometry. It was recommended among others, that since the treatment (van Hiele phase-based teaching strategy) were found to be effective in enhancing pre-service mathematics teacher achievements and attitude towards geometry, the strategy should be employed by lecturers in course of teaching the students. In addition, the strategy will provide a guide to teachers in their geometry teaching, and therefore reduce the challenges confronted by both teachers and pre-service mathematics teachers in the teaching and learning of geometry.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The system of education in Nigeria is currently based on 1-6-3-3-4 system involving three levels of institutional learning process; early childhood education (ECE) refers to as pre-primary, the primary education, secondary (junior and senior secondary education) and tertiary levels (Asaaju, 2015; FGN, 2013). At the age of five a child is enlisted into ECE, upon completion he/she at the age of six is registered into the primary school level. At this level he/she spends six years and on completion he/she is awarded the First School Leaving Certificate (FSLC), which, in combination with the common entrance examination, qualifies him/her to proceed to secondary school (Beter Future Foudation (BFF), 2002).

The secondary school education is split into two levels on the education system. The first phase is the junior secondary school level which lasted for three years. Students at this level after spending the three years, are required to take Junior Secondary School Examination (JSSSE) and the successful ones are offered the Junior Secondary School Certificate (JSSC). The JSSC is a requirement for the next phase - the Senior Secondary School (SSS), all of which lasted for three years. Upon the completion of this stage, students earn the Senior Secondary School Certificate (SSSC) after successfully passing the Senior Secondary School Examination (SSSE) (Asiyai, 2015).

Any students wishing to proceed to the tertiary level ought to have at the very least 5 credits including Mathematics and English. In addition, such student has to write and pass the Unified Tertiary Matriculation Examination (UTME), conducted by the

Joint Admission and Matriculation Board (JAMB) (FGN, 2013). The UMTE includes a compulsory paper for all the candidates who wish to study a particular course; Mathematics is however, compulsory for all science students Admission and Board (2012).

The tertiary level of Education offers the final phase and stage of educational system, lasting at a minimum of 4 years, concluding the 1-6-3-3-4 system of education. Institutions offering higher education in Nigeria include universities, polytechnics and colleges of education. Consequently, all of the 36 states, including the Federal Capital Territory Abuja, Nigeria have as a minimum of one institution of higher learning (BFF, 2002).

Colleges of Education which is the focal point of this study are recognized as the initial teachers training institution recognized by National Commission for Colleges of Education (NCCE) which is the agency that regulates the quality of students' intake and implementation of minimum curriculum standard in teacher training. The main aim of colleges of education is the production of teachers who are to teach at the secondary education level of Nigerian education system (NCCE, 2009). Mathematics is one of the courses in the curriculum of these colleges of education hosted in the school of sciences. The philosophy of mathematics programme in the colleges of education is however, "inspired by the desire to help students become intellectually informed in mathematical ideas, notations and skills for logical reasoning, scientific enquiry and for the pursuit of techno-scientific education and also the need to produce non-graduates but well-groomed and qualified professional teachers of mathematics for secondary education levels" (National Commission for Colleges of Education (NCCE), 2012, p.200).

The objectives of mathematics programme in the colleges of education as contained in the Minimum Standards for Nigeria Certificate in Education include:

a. Discuss with confidence the historical development of mathematics as a discipline
b. Solve abstract problems through the use of mathematic skills and ideas
c. Stimulate pupils' interests in mathematics by the use of appropriate teaching/learning strategies particularly at the basic education levels
d. Make learners appreciate the use of computers in solving mathematical problems
e. Use mathematics to solve day to day problems
f. Teach mathematics in a way that learners can apply mathematics principles in solving daily problems
g. Make the teaching of mathematics learner friendly through games and simulations
h. Set up a mathematics laboratory,
i. Improvise materials for effective teaching/learning of mathematics, and
j. To prepare the learners for further studies in mathematics and related courses (NCCE, 2012, p. 191).

Consequently, the pre-service teachers enrolled in the programme are expected to embark on a compulsory Teaching Practice before graduation (NCCE, 2012). A cursory look at the course outline reveals that geometry constitutes part of their course content. MAT 122, titled Coordinate Geometry, is one of the courses studied in the second semester of first year designed to prepare the pre-service mathematics teachers to teach students based on secondary school content (NCCE, 2012).

At secondary school level where, pre-service mathematics teachers are to practice and impact the knowledge and skills acquired during training, topics on geometry constitutes 38% of the Mathematics curriculum (Tsoho, 2011), and about 45% of total topics to be covered in the SSCE syllabus (WAEC, 2014). Accordingly, geometry, particularly at the lower levels functions as a background for understanding branches of geometry at higher level, as such it constituted a considerable section in Mathematics curriculum for all students in Nigerian secondary schools; this is obviously manifested in Table 1.1 in which geometry constitutes one-third of the questions in senior secondary school final examinations.

Table 1.1

Question Numbers Having Geometric Content Between 2010-2016

Year	**Question Number**	**% (n=10)**
2010	3, 4, 6, 9, 10	50
2011	2, 4, 8	30
2012	3, 5, 12	30
2013	5, 7, 10	30
2014	1, 4, 9, 10	40
2015	2, 3, 11	30
2016	3, 4, 7, 10	40

Source: West African Examination Council (WAEC)

In view of the above, geometry has been perceived as the center or rather the focal point of mathematics (Mlodinow, 2001). It is an arm of mathematics that adderesses properties and relations of constructible plane figures, and also the specific mathematical axiomatization of the properties and relations of plane shapes as studied, for instance, under Euclidean Geometry (Atebe, 2008). In other subject areas such as engineering drawing and geometry drawing, geometry is applied (Abdullah & Zakaria, 2013b). Mak (2016) observed that relevancy of geometry is essential in assisting

learners to comprehend better the foundamental mathematics concepts such as number lines which are frequently employed in studying elemetry skill of arithmetic, addition and subtraction, directed numbers and linear inequalities. Furthermore, Chew and Lim (2013) affirmed the position of learning geometry. According to them, geometry is a vital skill to learn other topics in mathematics such as fractions, decimals, percentage, functions and calculus. Accordingly, Abdullah and Zakaria (2013b) opined that enhancing comprehension in this field can help learners to effectively resolve difficulties faced in geometry and similarly develop learner's visual ability and consequently raise the aesthetic value of shapes which thereafter will improve geometry achievement of the learner.

In spite of the important role that geometry and mathematics in general play both as academic discipline and as knowledge that everybody needs in the society as specified in the National Policy on Education (FGN, 2004), it is the worst performed topic in mathematics in all Nigerian internal and external examinations making the overall Mathematics performance very poor (Chief Exerminer report WAEC, 2012 2013, 2014; Gimba, 2003; NECO, 2012; Obodo, 2004; Osemwinyen, 2009). Going by these statements, Pussey (2003) and Atebe (2008) conceived that academic achievement in Mathematics is a very good pointer to academic achievement in geometry specifically. Ogundele, Olanipekun, and Kola, (2014) however lamented that the situation in respect of poor performance of students is so pitiful that interested parties keep on doubting the reason why this level of education is constantly unsuccessful in meeting the desires and aims of the society.

The disparities observed in poor mathematics performance across the nations is a matter of concern (UNESCO, 2012). It is on this note that Ifamuyiwa and Ajilogba, (2012) observed that Nigeria's performance among eleven of the entire English-

speaking West African nations in the West Africa Senior Certificate Examination (WASCE) was nothing to write home about because, Nigeria took second to the last position. It has also been observed both nationally and internationally that, upon finishing elementary education, majority of the students' mathematics knowledge and preparedness is below expectation (Hassan, 2015). For instance, a close look at the global context, the comparative study of Mathematics and Science performance of students indicates that United States students who are advanced in terms of science and technological development fall behind many countries in geometry content area. United States students' perfomance dropped and was rated third from bottom of all nations tested, 38 countries perform better than the US in geometry with Japan taking the first position with a score of 575 and international average of 473 in geometry (Mullis, Martin, Foy & Arora 2012). Research findings world over, have also affirmed that among the abstract and complex features of mathematics which learners discovered problematic to learn, and few teachers find tough to teach with the absence of instructional model is geometry (Akinlade, 2004).

Benjamin and Agwagah (2006) and Unal (2005) came up with helpful findings on the factors leading to learners' poor academic achievement in mathematics and geometry at all levels of education. Several studies by researchers have seen teachers' subject matter incompetency as a contributory factor. For instance, Sanchez and Lopez (2011) observed that few of the existing difficulties in the teaching and learning of mathematics particularly geometry may be attributed to deficiency of mathematical understanding of learners learning to be teachers. In another related development, Ali, Bhagawati, and Sarmah (2014), NCTM (2000), and Sunzuma, Masocha and Zezekwa (2013) in their separate submissions attributed cause of poor academic achievement to inappropriate method of teaching and learning mathematics in schools.

Hassan (2015) in his opinion ascribed shortage of required knowledge and ability in both the content and delivery as causes of under achievement. He maintained that, result has over the years shown that, mathematics teachers teaching in schools do not have the understanding of mathematics expected as a precondition to effective teaching. Furthermore, appropriate knowledge for specific knowledge as in pedagogy is said to be deficient by mathematics teachers as purported by Odili (2006) and Ohakwe (2006) who reported that even though the call to use approaches like discovery, laboratory activities, individual problem solving and other techniques, mathematics teachers still follow conventional teaching strategy. In a related development, Unal (2005) opined that one possible reason why students perform poorly in geometry is that, mathematics teachers are failing to offer their students with proper learning opportunities in geometry. Ifamuyiwa and Ajilogba, (2012) also observed that non-utilization of proper teaching methods and over dependence on conventional teaching strategies thus results to rote-learning and low performance.

Nonetheless, Rico (2012) and Sierra (2011) stressed that resolving these specialized tasks is a thing that can be anticipated of the research predominantly in mathematics teaching. As such, Hassan (2012) observed that mathematics educators have now directed their energy and resources towards search for alternative and more appropriate method for mathematics education instruction. Findings from a study conducted by Curriculum Development Centre, Ministry of Education, Malaysia in 2002 cited by Ifamuyiwa and Ajilogba (2012), observe that students lack knowledge of how to translate challenges involving shapes, pictures, and which requires students' creativity is observed to be problem confronting geometry learning. Another area of great concern for mathematics teaching which requires urgent intervention is the ability of pre-service mathematics teachers to be conversant with foundational skills

which would help in building the skills of logic, deductive reasoning, analytical reasoning and problem solving (Russell, 2014).

Research findings show that pre-service mathematics teachers' preparations with specific emphasis on developing a structure of mathematics in Nigerian universities and colleges are totally insufficient (Odili, 2006; Tahir, 2008). Consequently, current practice of teaching and learning in the classrooms do not exibit the position of geometry in the students' lives, and the particular attention that is expected to be bestowed to geometry topics in the mathematics curriculum (Abdullahi & Zakaria, 2013b). In view of this, practice of teaching is still bound to the conventional method which is teacher centered (Mullis et al., 2000).

Indeed, learning is built on what takes place in the classroom and not only on what students do because teaching environment is vital for learning (Lin-Siegler, Dweck & Cohen 2016). Psychologists and educationists believed that learning makes sense only when the learner can make sense of the world and are able to discover essential relationship through interaction with appropriate environment (Amineh & Asl, 2015). Hence, approaches to teaching should be in such a way that it would be appropriate for a particular context, age and developmental stages of the learner. As a result of this, Sanchez-Garcia and Cabello (2016) affirmed that being aware of the difficulties faced in the area of teaching and learning, additional research mostly in education is required to approach the malfunctions discovered in research reports assessing the educational systems. One possible way to achieve this, as reported by Johnson, and Johnson (1999), is by giving the students the chance to reason and communicate mathematically and improve self- confidence to explain problems in mathematics. Therefore, investigating the utmost distinctive theory in area of study such as this, led to the desire to employ van Hiele's geometric model.

The van Hiele's geometric model describes how children learn to reason in geometry. It consists of five levels and five phases of instruction which have been applied in many studies (Abdullah & Zakaria, 2013b; Abu et al., 2012; Alex & Mammen 2016; Atebe, 2008; Chang et al., 2007; Chew, 2007; Chew, & Lim, 2013; Erdogan & Durmus, 2009; Fuys et al., 1988; Hoffer, 1983; Usiskin, 1982) that are related to teaching and learning of geometry and it was however found to be effective in developing students' academic achievement. The model was developed by two Dutch mathematicians in the 1950s, Pierre van Hiele and his wife Dina van Hiele-Geldof. The five levels according to van Hiele (1986) are: Recognition, Analysis, Order, Deduction and Rigor.

These levels are attained as a result of experience and instruction rather than age. Therefore, a learner is required to have enough knowledge of (classroom or otherwise) geometric thoughts for him to shift to a higher stage of complexity. That is to say that the feature of the model is hierarchical in nature. Each of the levels (levels 1 – 5) is accompanied by five phase-based instruction strategies. Chew (2009) and Choi-Koh (2000) confirmed this by saying that learners have to go through the entire five phases to be able to achieve each of van Hiele's level. The point here is according to van Hiele, each level of geometry classroom instruction is attained as a result of sequence of the phases. The five phases of instruction are: Information, Guided orientation, Explicitation, Free-orientation and Integration. At this point, when a teacher is able to raise level of geometry instruction process as a result of phase-based instruction, it will help student to develop positive attitude towards mathematics.

Attitudes in teaching and learning process are well-established structures of positive or negative assessment, enthusiastic emotion and dispositions to social objects (Knezek & Christensen, 2018). It can be explained as stable conduct or rather manner

of reacting, as portrayal of feeling or opinion. It could also be referring to as a specific tendency to perform or respond in a positive or negative direction with a view towards specific circumstances and ideas (Issa, Bashorun, Mubashir, & Adewusi, 2010). Bowen, Bowen and Richman (2000) conceived attitude as a combination of personal choice about a particular element. Researchers such as Pavlovicova and Zahorska (2015) opined that positive attitude towards geometry leads learner to success in mathematics. They maintained that effort to enhance attitude towards mathematics at basic level offers foudation for advanced studies in mathematics, and similarly impacted positively on mathematics achievement at a particular school level. The connection between attitude and achievement was found in the theory of reason which according to Karen and Rimer (2015), rest on basic belief that the greatest indicator of a behavior is intention, which is decided by the attitude towards social normative perception regarding the behavior. This means that immediately a group of people are positively inclined to a behaviour, they are likely to take up the conduct. This was therefore confirmed by Nwagbo (2006) that the enhancement of the proper mentality to learning by learners is central to the realisation of excellent achievement in that learning.

Gender and achievement levels of students are another area examined in this study. It is one area which has been severally repeated throughout literatures in mathematics education and academic studies in general (Mata, Monteiro, & Peixoto 2012). According to Hassan (2015), "the term gender is important in Science, Technology, and Mathematics (STM) because, it described the social definition of sex role rather than distinct biological distinction itself, STM is seen as subject of male and the female" (p. 42). Mathematics generally is frequently taking into consideration as one area in which males are considered to be higher achievers, in terms of both

attitudes and self-concept (Mata, 2012). On the other hand, Lindberg, Hyde, Petersen, and Linn, (2010) and Scafidi and Bui (2010) in their separate results indicates that there is no substantial difference on mathematics achievement and grades based on gender. Finding relating to gender differences on attitudes is not stable. Few studies have stated significant differences upon comparing attitudes towards mathematics based on gender (Asante, 2012; Eshun, 2004). However, there exist quite a number of studies in which these differences are not noticeable (Mohamed & Waheed, 2012). Therefore, there is need to examine the interaction effect of gender and geometry achievement within the Nigerian school context on students' geometry achievement.

Retention is one of the variables of this study, this is because researchers such as Gambari, Falode, and Adegbenro (2014) and Udousoro (2002) has shown inconsistent findings on the variables that may lead to students retaining more of what they have learnt. Retention, however, is defined by Gambari, Falode, and Adegbenro (2014) as the ability to reproduce what was previously learnt when the need arises. In the view of Bell and Kozlowski (2008), retention means direct relationship of progressive or positive knowledge already learned. To this end, therefore, it means that retention could give rise to high academic achievement which is an aspect of several variables like teaching strategies/methods, period between teaching and learning and recovery among others. In the view of Osemwinyen (2009), an appropriate instructional strategy could arouse and retain student academic achievement.

Accordingly, the concern of any mathematics teacher is to integrate into teaching practices the contributions originated from the area of educational research, especially concerning geometry teaching in order to offer effective teaching model. After carefully going through literature on van Hiele theory of instruction, the researcher is of the view that mathematics teacher with knowledge of van Hiele's

phase-based teaching strategy can make available appropriate lessons structure and other apparatus, develop activities and experience for the learner so that understanding would grow from within. This is because it describes how to move up the level of instruction processes. Undeniably, it implies providing awareness to mathematics teaching of interconnecting components in-built for teaching geometry. In view of this, the study attempted to determine the effects of van Hiele's phase-based teaching strategy and gender on pre-service mathematics teachers' geometry achievement and attitude towards geometry in Niger state, Nigeria.

1.2 Statement of the Problem

The consistent poor academic achievement of students at all level of education in mathematics generally and geometry in particular in Nigeria has been a matter of concern to mathematics educators, mathematician and stake holders (Bello, & Isma'il 2017). This therefore compelled the federal government of Nigeria to initiate the reforming of teacher education program targeted to provide standard, well-versed, skilled and expert teachers (Akande & Olorundare, 2012). In line with the federal government directive, a substantial amount of researches were conducted by various departments in teachers´ training institutions on how to improve the academic achievement of prospective teachers (pre-service teachers), along with preparing them to teach at secondary school level, but in spite of all these great attempts and efforts, the challenges of under achievement among learners still continued to be on the increase (Ojaleye & Awofala, 2018). In confirmation of this, the results of pre-service mathematics teachers in geometry, a course offered in second semester between 2013 to 2016, is so poor that the department and the entire college are almost getting disturbed over the situation (Department of Mathematics, 2016). In addition, this can

be further substantiated by the researcher's personal experience at college of education setting, in the midst of the nine courses offered in the first year of pre-service mathematics teachers, MAT 122 titled Coordinate Geometry always records the worst result. In addition, pre-service mathematics teachers hardly attempt questions from prerequisite course such as Vector Analysis and Statics involving application of geometry in their second and third years respectively. In this case majority of the pre-service mathematics teachers often recopy the questions as such they tend to obtain low or failure grades when the final result is released. Consequently, they tend to develop negative attitude towards geometry and mathematics in general. These negative attitudes developed are evidences from the derogatory comments often made about geometry, as being difficult and this therefore affects their attitude towards geometry.

Numerous factors according to Hassan (2015) were responsible, some of the factors range from; inability of pre-service teachers to solve geometric problems, deficiencies in verbal and visual skills, inadequate skill for effective teaching and learning and lastly ineffective instructional practices by teachers. In addition to some of the problems that still persist in training teachers is that teachers themselves lack teaching skills and as such makes transformation of pre-service teachers from the learners of mathematics to a mathematics teacher difficult (Ohakwe, 2006). Thus, more attention is needed in this area than it currently receives with regard to mathematics teacher education, this is because, it appears that the maximum and equal benefit to be derived by the pre-service mathematics teachers from the domain of their teacher preparation has not been adequately demonstrated in their instructional practices as reflected in the student poor academic achievement in geometry as provided in the chief examiner's report (WAEC, 2012, 2013, 2014).

To arrest the situation, several teaching strategies have been employed such as Cooperative teaching method, inquiring method, computer assisted instructional package, concept mapping et cetera. Nevertheless, these teaching strategies have not produced satisfactory results within pre-service teachers (Hassan, 2015). Hence the quest for effective mathematics teaching strategy becomes necessary.

Several studies (Abdullahi & zakari, 2013b; Abu et al., 2012; Alex & Mammen 2016; Cannizzaro & Menghini, 2006; Chang et al., 2007; Chew, 2007; Chew & Lim, 2013; Erdogan & Durmus, 2009) have been carried out, validated and discovered to be effective in teaching and learning of geometry as a result of various studies carried out globally, it was however, established that van Hiele geometry model facilitates learning. To be specific, in Russia, a research was carried out in which van Hieles' model was applied to school mathematics curriculum and the result revealed that the model produced appreciable development in students' understanding of school geometry (Fuys et al., 1988; Hoffer, 1983). Similarly, in the U.S., three similar federally-funded investigations (the Oregon Project, the Brooklyn Project, and the Chicago Project) were conducted between 1979–1982 (Hoffer, 1983), and the result revealed that in all these projects van Hiele's model have shown to be a useful framework for accessing and unravelling students' difficulties with school geometry (Hoffer, 1983).

However, in spite of the widespread application of the van Hiele theory to improve geometry classroom instruction in many Western countries and Asia, literature appeared to suggest that there is limited research that specifically examines pre-service mathematics teachers' academic achievement and attitude employing van Hiele's teaching strategy in African context, Nigeria in particular.

Consequently, the worth of this current research therefore rests on the fact that inspites of huge numbers of researches already carried out on van Hiele model, much emphasis were laid on geometric thinking level which as a result confirmed the appropriateness of first three levels for secondary school students (Burger & Shaughnessy 1986; Fuys et al. 1988; Mayberry, 1983; Usiskin, 1982). Hence, it became pertinent to carry out research on pre-service mathematics teachers' achievement and attitude as the poor achievement of learner in mathematics, geometry in particular has been a topic of concern over the past decades.

In view of the above, the sole interest of a researcher as at present time is the habitual gender differences in the world and its impact on sevaral phases of human activities (Dangpe, 2015). According to Ajai and Imoko (2015) and Yusuf and Onasanya (2004), findings have shown that there were significant differences in the academic achievement based on gender while other findings indicated that gender factor had no effect on students' academic achievements. Adesoji and Fisuyi (2001), Ifamuyiwa (2004), Kovas et al. (2015), Musa et al. (2016) and Preckel et al. (2008) in their separate researches show that male students outperform their female counterparts in mathematics and science related subjects at secondary school level. In contrast, Contini at al. (2016), Gimba (2003) and Olson (2002) noted that female students outperformed their male partners. Other researches such as Egorova and Chertkova (2016), Orabi (2007), and Iwendi and Oyedum (2014) revealed no gender differences in achievement of males and females in mathematics and science subjects. However, on a larger scale research, such as Trends in International Mathematics and Science Study (TIMSS) has found that "there were no gender differences in 22 of the 42 countries that tested at Year 8, including Australia" (Thomson, Hillman, Wernet, 2012, p. 20). In view of this, there is call and need to investigate more on gender differences

in Nigerian school context on pre-service mathematics teachers' achievement based on present trend in the world and attention given to gender matters in the millennium statement of September 2000 (United Nations, 2000) which has it as its aims, the advancement of gender equity, the women empowerment and the eradication of gender disparity in elementary and secondary education and at entire levels by 2015 with a view of suggesting possible intervention strategies.

Information on whether attitude of student towards mathematics and geometry improve students' academic achievement is much less clear on the basis of the controversial findings from the literature. Nicolaidou and Philippou (2003) observed that a learner developed positive attitude towards mathematics during first time in school, yet, as they advance their attitudes assume less positive and oftentimes become negative at high school. Negative attitudes are the autcome of regular and recurrent challenges when addressing mathematical tasks and these might become somewhat steady if measures are not taken (Petty, 2018). There are collection of circumstances explaining reason why learners' attitude to mathematics turn out to be negative with the school grade. These includes; the tension to perform excellently, over demanding tasks, uninteresting lessons and less positive attitudes on the part of teachers (Nicolaidou & Philippou, 2003). Hence, there is need to investigate as to whether instructional strategy will have effect on the attitude of pre-service mathematics teachers towards geometry.

Motivated by the earlier research connected to possible positive impact of teaching strategy on retention of pre-service teachers, this study intends to investigate on the inconsistent findings on the variables that may lead to the students retaining more of what they have learnt (Gambari, Falode, & Adegbenro 2014; Udousoro 2002). These inconsistent findings call for continuous research particularly with teaching

strategies to bring equity in retention in geometry. Therefore, this study would find out the effect of teaching strategy (van Hiele phase-based instructional strategy) on geometry retention of pre-service mathematics teachers. Again, this research seeks to investigate the effect of teaching approach based on gender on pre-service mathematics teachers' retention in geometry.

The rationale behind investigating the effect of retention of attitude towards geometry, as well as eliciting the strengths, weaknesses of van Hiele phase-based teaching strategy and suggestions to improve it from both pre-service mathematics teachers and lecturer perspectives, was inspired by the non-availability of studies from literature on these variables. To the best of my knowledge from the reviewed work, no study was conducted specifically focusing on retention of attitude towards geometry and pre-service mathematics teachers, and lecturer view on the strengths, weaknesses of a particular teaching strategy.To this end, this study intends to obtain empirical evidence in order to fill the existing gap noticed in the literature.

Consequent upon the above, in an attempt to seek a teaching strategy that can improve pre-service mathematics teacher academic achievement, this study investigates effects of van Hiele's phase-based teaching strategy and gender on pre-service mathematics teachers' geometry achievement and attitude towards geometry in Niger state, Nigeria.

1.3 Aim and Objectives of the Study

The aim of this study is to determine the effects of van Hiele's phase-based teaching strategy and gender on pre-service mathematics teachers' geometry achievement and attitude towards geometry in Niger state, Nigeria.

Specifically, the research objectives were as follows:

1. Determine the effects of teaching method and gender on pre-service mathematics teachers' achievement in geometry.
    a) Determine the main effect of teaching method on pre-service mathematics teachers' achievement in geometry.
    b) Determine the main effect of gender on pre-service mathematics teachers' achievement in geometry.
    c) Determine the interaction effect of teaching method and gender on pre-service mathematics teachers' achievement in geometry.
2. Determine the effects of teaching method and gender on pre-service mathematics teachers' attitude towards Geometry.
    a) Determine the main effect of teaching method on pre-service mathematics teachers' attitude towards Geometry.
    b) Determine the main effect of gender on pre-service mathematics teachers' attitude towards geometry.
    c) Determine the interaction effect of teaching method and gender on pre-service mathematics teachers' attitude towards geometry.
3. Determine the effects of teaching method and gender on pre-service mathematics teachers' retention of achievement in geometry.
    a) Determine the main effect of teaching method on pre-service mathematics teachers' retention of achievement in geometry.
    b) Determine the main effect of gender on pre-service mathematics teachers' retention of achievement in geometry.
    c) Determine the interaction effect of teaching method and gender on pre-service mathematics teachers' retention of achievement in geometry.

4. Determine the effects of teaching method and gender on pre-service mathematics teachers' retention of attitude towards geometry.
    a) Determine the main effect of teaching method on pre-service mathematics teachers' retention of attitude towards geometry.
    b) Determine the main effect of gender on pre-service mathematics teachers' retention of attitude towards geometry.
    c) Determine the interaction effect of teaching method and gender on pre-service mathematics teachers' retention of attitude towards geometry.
5. Elicit the strengths, weaknesses of van Hiele's phase-based teaching strategy and suggestions to improve it from the pre-service mathematics teachers' perspective.
6. Elicit the strengths, weaknesses of van Hiele's phase-based teaching strategy and suggestions to improve it from the lecturer's perspective.

1.4 Research Questions

In an effort to assess pre-service mathematics teachers' geometry achievement and attitude towards geometry, the following research questions are raised:

1a. Is there any significant main effect of teaching method on pre-service mathematics teachers' achievement in geometry?

b. Is there any significant main effect of gender on pre-service mathematics teachers' achievement in geometry?

c. Is there any significant interaction effect of teaching method and gender on pre-service mathematics teachers' achievement in geometry?

2a. Is there any significant main effect of teaching method on pre-service mathematics teachers' attitude towards geometry?

b. Is there any significant main effect of gender on pre-service mathematics teachers' attitude towards geometry?

c. Is there any significant interaction effect of teaching method and gender on pre-service mathematics teachers' attitude towards geometry?

3a Is there any significant main effect of teaching method on pre-service mathematics teachers' retention of achievement in geometry?

b. Is there any significant main effect of gender on pre-service mathematics teachers' retention of achievement in geometry?

c. Is there any significant interaction effect of teaching method and gender on pre-service mathematics teachers' retention of achievement in geometry?

4a. Is there any significant main effect of teaching method on pre-service mathematics teachers' retention of attitude towards geometry?

b. Is there any significant main effect of gender on pre-service mathematics teachers' retention of attitude towards geometry?

c. Is there any significant interaction effect of teaching method and gender on pre- service mathematics teachers' retention of attitude towards geometry?

5. What are the strengths, weaknesses of van Hiele's phase-based instructional strategy and suggestions to improve it from the pre-service mathematics teachers' perspective?

6. What are the strengths, weaknesses of van Hiele's phase-based instructional strategy and suggestions to improve it from the lecturer's perspective?

1.5 Null Hypotheses

The null hypotheses were formulated from the corresponding research questions raised above.

The null hypotheses of the study were as follows:

H_o1a: There is no significant main effect of teaching method on pre-service mathematics teachers' achievement in geometry.

1b: There is no significant main effect of gender on pre-service mathematics teachers' achievement in geometry.

1c: There is no significant interaction effect of teaching method and gender on pre-service mathematics teachers' achievement in geometry.

H_o2a: There is no significant main effect of teaching method on pre-service mathematics teachers' attitude towards geometry.

2b: There is no significant main effect of gender on pre-service mathematics teachers' attitude towards geometry.

2c: There is no significant interaction effect of teaching method and gender on pre-service mathematics teachers' attitude towards geometry.

H_o3a: There is no significant main effect of teaching method on pre-service mathematics teachers' retention of achievement in geometry.

3b There is no significant main effect of gender on pre-service mathematics teachers' retention of achievement in geometry.

3c There is no significant interaction effect of teaching method and gender on pre-service mathematics teachers' retention of achievement in geometry.

H_o4a: There is no significant main effect of teaching method on pre-service mathematics teachers' retention of attitude towards geometry.

4b There is no significant main effect of gender on pre-service mathematics teachers' retention of attitude towards geometry.

4c There is no significant interaction effect of teaching method and gender on pre-service mathematics teachers' retention of attitude towards geometry.

1.6 Significance of the Study

The results of this research study will provide useable insight to teachers, pre-service mathematics teachers, curriculum planners, policy makers, government and the country as a whole in the following ways:

It will provide a guide to teachers in their geometry teaching, and therefore reduce the challenges confronted by both teachers and pre-service mathematics teachers in the teaching and learning of geometry. In this way it will serve to guide the teacher with an outline or plan to be employed when conducting geometric activities.

In addition, since it was found out from literatures that there is dearth of empirical evidence in Nigeria's context linking van Hiele model with pre-service mathematics teachers' achievement, hence this study will significantly contribute towards closing the perceived gap in the existing literature. Likewise, this research would provide assistance to stakeholders in the development of curriculum particularly in the aspect of decision making in the development of mathematics curriculum, as the school curriculum is generally the major factor in shaping the quality of education.

The research would help lay off pre-service mathematics teachers' general negative attitude towards mathematics and geometry in particular which would influence their learning of mathematics positively even after completing their programme. Also, the study will add new knowledge to mathematics education beside serving as a reference point at the library for learners particularly in the teaching of mathematics education and indeed the general public.

The National Examination bodies such as the West African Examination Council (WAEC), National Examinations Council (NECO), National Board for

Technical Examinations (NABTEC), National Teachers Institute (NTI) will also find this study very beneficial in the aspect of tests construction and validation.

The professional bodies for instance the Mathematical Association of Nigeria (MAN) and Science Teachers Association of Nigeria (STAN) who normally meet annually to update members on recent research findings will also derive some benefits from the result of this study. In this process, the result of the study will assist in updating the members' knowledge of the most current study at this point in time in the field of mathematics education.

Furthermore, the result will be helpful to text book writers in shifting emphasis from teachers-centred to learners centred activities such as van Hiele's phase-based teaching strategy that will promote learning in the teacher's manual/teacher's guide.

Similarly, van Hiele's phase-based teaching strategy is gender friendly since it improved the academic achievement of male and female students equally. Thus, mathematics teachers should employ these strategies to increase female students' academic achievement in mathematics as this will bridge the gender gap among students at all level.

Lastly, this study strives to contribute to knowledge in the area of teaching method to be employed in the teaching of Mathematics. Hence, the improvement as observed in this study has come as a unobjectionable improvement to answer the difficulties of insufficient teaching model for teaching mathematics in the colleges of education in Nigeria. The teaching strategy has also come as a practical master plan for lecturers as well as pre-service teachers to follow with a view to effectively incorporate van Hiele's teaching strategy into their teaching.

1.7 Limitations of the Study

Limitations according to Best and Khan (2006) refers to the situations that are beyond the regulation or control of the investigator that might have restriction on the outcome of research. This study therefore was restricted to mathematics teachers' preparation in colleges of education (pre-service mathematics teachers). Precisely, the geometry achievement was looked into using the van Hiele's Geometric Model "Teaching Phases" in geometry teaching at college of education levels.

The study involves two colleges of education in Niger State, namely; College of Education A and Federal College of Education B. In addition, the non-existence or rather dearth of research regarding the van Hiele model in Nigeria's mathematics curriculum was also a limitation. The researcher was unable to draw from local examples and knowledge.

Test item in this study is limited to geometry achievement test to measure the extent of geometry achievement of pre-service mathematics teachers involved in the study. The basis for evaluation was therefore limited to the items within the Geometry Achievement Test. The aspect of mathematics concepts focused is straight lines and circles. And lastly, this study was carried out within the context of classroom**.**

1.8 Operational Definition of Terms

The following variables and terminologies were defined operationally as was used in this study.

1.8.1 Van Hiele's phase-based teaching strategy

Learning process suggested by van Hiele leading to complete understanding of the five phases of the teaching strategy namely: information/inquiry, guided/directed