INFLUENCE OF MATHEMATICS VOCABULARY TEACHING ON PRIMARY SIX LEARNERS' PERFORMANCE IN GEOMETRY IN SELECTED SCHOOLS IN THE GREATER ACCRA REGION OF GHANA

BY

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Submitted in accordance with the requirements for the degree of

PhD in EDUCATION

in the subject of

MATHEMATICS EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA (UNISA)

SUPERVISOR: PROFESSOR MG NGOEPE

DECEMBER 2020

DECLARATION

I, Ngozi Obiageli Orevaoghene, declare that THE INFLUENCE OF MATHEMATICS VOCABULARY TEACHING ON PRIMARY SIX LEARNERS' PERFORMANCE IN GEOMETRY IN SELECTED SCHOOLS IN ACCRA REGION OF GHANA is my own work and has not previously been submitted for examination at UNISA for another qualification or to any other institution of higher education. All sources cited or quoted are acknowledged via a comprehensive list of references.

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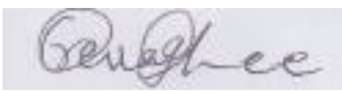

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ABSTRACT

The study investigated the strategies used in teaching geometry in primary six as well as the perception of teachers on geometry vocabulary teaching, how geometry vocabularies were taught and, lastly, how the teaching of geometry vocabulary influenced primary six learners' performance in geometry. The Van Hiele Theory of geometrical thinking and the Constructivist Theory of learning guided the study. The study conveniently sampled 250 primary 6 learners and 7 primary 6 mathematics teachers from three privately-owned primary schools in the Greater Accra Region of Ghana. It combined quantitative and qualitative approaches, using O1–X–O2 design. Data collection instruments were 5-point Likert type scale questionnaires (one for teachers, one for learners), a pre-test and post-test of basic geometry, and a semi-structured one-on-one audio-recorded interview of a selected number of learners and all seven teachers. An intervention was carried out in-between the pre-test and post-test, where the researcher taught geometry vocabulary to participants. Quantitative data were analysed using tables, charts, and simple tests while the qualitative analysis involved the transcription of interviews that were coded, categorised and themed. The study found that geometry vocabularies were not taught and that the most commonly used strategy for teaching geometry was the drawing of 2-D shapes and models of 3-D objects on the board. The pre-test and post-test scores were analysed using a paired t-test and the results indicated that the intervention had a positive effect. The qualitative and quantitative results confirmed that the teaching of geometry vocabulary improved learners' performance in geometry. The study developed a prototype lesson plan for teaching 3-D objects, a geometry vocabulary activity sheet, a sample assessment for prisms and pyramids and recommends a curricular reform to inculcate the teaching of geometry vocabulary in the curriculum with a geometry vocabulary list for learners in each year group, as contribution to knowledge in mathematics education. The study recommends further research to investigate the effect of geometry vocabulary teaching on learners' performance in geometry across all year groups in the primary school.

KEYWORDS:

Geometry strategies; drawing shapes; pictures of solid objects; 2-D shapes; 3-D objects; mathematics vocabulary; geometry vocabulary; influence of vocabulary teaching; geometry performance; primary school geometry teaching.

MAVONELO

Dyondzo a yi lavisisa maendlelo lawa ya tirhisiwaka ku dyondzisa geometry ya tidyondzo ta le hansi ta ka ntsevu, mavonelo ya vadyondzisi eka madyondziselo ya marito ya geometry, tindlela leti tirhisiweke ku dyondzisa marito ya geometry xikan'we ni ndlela leyi madyondziselo ya marito ya geometry ya khumbheke matirhelo ya vadyondzi va tidyondzo ta le hansi ta ka ntsevu. Dyondzo ya ndzavisiso yi leteriwile hi ehleketelelo ra Van Heile ra maehleketelelo ra ndlela ya geometry ni ndlela yo dyondzisa leyi pfumelelaka vadyondzi ku vumba vutivi ku nga ri ntsena ku teka vutivi ku suka eka mudyondzisi. Dyondzo ya vulavisisi yi hlawurile vana va 250 va tidyondzo ta le hansi ta ka ntsevu na 7 wa vadyondzisi va tnhlayo ta tidyondzo ta le hansi ta ka ntsevu kusuka eka swikolo swinharhu swo ka swi nga ri swa mfumo e Greater Accra etikweni ra Ghana. Yi hlanganisile qualitative na quantiutative aapproach, yi tirhisa O1–X–O2 design. Switirhisiwa swo hlengeleta data a swi ri swivutiso hi muxaka wa 5-point scale(yin'we ya vadyondizi, yin'we ya vadyondzi), xikambelwana xo rhanga na xo hetelela xa geometry ya masungulo, xikan'we na nkandziyiso wa mburisano wa vanhu vambirhi eka nhlayo ya vadyondzi ni vadzyondzisi hinkwavo va nkombo. Ntirho wo nghenelerisa wu endliwile exikarhi ka xikambelwana xo rhanga ni xo hetelela laha mulavisisi a nga dyondzisa marito ya geometry eka vanhu lava ngheneleleke. Quantitative data yi hleriwile hi ku tirhisa matafula, ti charts ni swikambelwana swo olova kasi vuhleri bya qualitative byi nghenise kutsariwa ka miburisano leyi hundzuluxiweke yi nyika tinhlamuselo leti tumbeleke. Leti vekiweke hi ku ya hi mintlawa ni maendlelo ya tona. Dyondzo ya ndzavisiso yi kume leswaku marito ya geometry a ya dyondzisiwanga ni leswaku maendlelo yo toloveleka ya ku dyondzisa geomeyry i ya drawing ya xivumbeko xa 2-D ni mfanekiso wa nchumu wa 3-D eka bodo. Mbuyelo wa Xikambelwana xo sungula na xo hetelela wu hleriwile hi ku tirhisa t-test (xikambelwana xa T) lexi hlanganisiweke naswona mbuyelo wu komba leswaku maendlelo himkwawo ya vile ni xiave lexinene. Mbuyelo wa Qualitative na Quantitative wu tiyisisile leswaku ku dyondzisiwa ka marito ya geometry swi antswisa matirhelo ya vadyondzi eka dyondzo ya geometry. Dyondzo ya vulavisisi yi antswisile kumbe ku kurisa prototype lesson plan ya ku dyondzisa 3-D objects, sheet ya migingiriko ya marito ya geometry na ku bumabumela circular reform ku dyondzisa madyondziselo ya marito ya geometry eka kharikhulamu leyi ng na nxaxamelo wa marito ya geometry ya vadyondzi eka ntlawa wa lembe na lembe, ta ni hi mpfuneto wa vutivi eka dyondzo ya tinhlayo. Dyondzo ya vulavisisi yi bumabumela leswaku vulavisisi byi ya emahlweni ku lavisisa xiave xa madyondziselo ya marito ya geometry eka matirhelo ya vadzyondzi eka geometry eka malembe ni mintlawa hinkwayo exikolweni xa le hansi.

MARITO YA NKOKA:

Maendlelo ya geometry; ku dirowa swivumbeko; swifaniso swa swilo; swivumbeko swa 2-D; swilo swa 3-D, marito ya dyondzo ya tinhlayo(metse); marito ya geometry; matimba yaku va na xiave eka madyondziselo ya marito; matirhelo (mbuyelo) eka geometry; madyondziselo ya geometry eka tidyondzo ta le hansi.

KAKARETŠO

Thuto ye e nyakišišitše ditsela tšeo di šomišwago go ruteng ga geometry go mphato wa bo tshelela, temogo ya barutiši go ruteng tlotlontšu ya geometry, tsela yeo ditlotlontšu tša geometry di rutilwego ka gona go akaretšwa le, sa mafelelo, ka mokgwa wo thuto ya tlotlontšu ya geometry e tutueditšego mabokgoni a barutwana ba mphato wa bo tshelela go dithuto tša geometry. Thuto ya *van Hiele ya geometrical thinking* le ya *constructivist theory of learning* di hlahlile thuto ye. Thuto ye e šomišitše ga bonolo mohlala wa barutwana ba 250 ba mphato wa 6 le barutiši ba dipalo ba šupa ba go ruta mphato wa 6 go tšwa dikolong tša tlase tše tharo tša go ikema seleteng sa Greater Accra Region of Ghana. Thuto ye e kopantše mekgwa ya bontši/dipalopalo (quantitative) le boleng (qualitative), go šomišwa tlhamo ya O1-X-O2. Didirišwa tša kgobaketšo ya boitsebišo e bile *5-point Likert Type Scale Questionnaire* (ye tee ya barutiši, ye tee ya barutwana), moleko wa pele le moleko wa morago wa geometry ya motheo, le poledišano yeo e gatišitšwego ya tlhamego ya sewelo (semi-structured) ya barutwana bao ba kgethilwego ga mmogo le barutiši ka moka ba šupa. Thekgo e ile ya phethagatšwa/fiwa magareng ga moleko wa pele le moleko wa morago moo monyakišiši a rutilego tlotlontšu ya geometry go batšeakarolo. Boitsebišo bja bontši (quantitative data) bo sekasekilwe ka go šomiša ditafola, ditšhate, le teko e bonolo mola ditshekatsheko tša boleng (qualitative analysis) di akareditše go ngwalolla dipoledišano tšeo di thulagantšwego, tša hlophiwa le go beakanywa ka sehlogo. Thuto ye e itullotše gore ditlotlontšu tša geometry ga se tša rutwa ebile mekgwana yeo e šomišitšwego ya setlwaedi go ruta geometry ebile go thala dibopego tša 2-D le mehlala ya didirišwa tša 3-D letlapeng. Dintlha tša moleko wa pele le moleko wa bobedi di sekasekilwe ka go šomiša mokgwa wa go phera moleko wa t (t-test). Dipoelo di šupeditše gore thekgo yeo e filwego e bile le khuetšo ye botse. Dipoelo tša bontši le boleng di netefaditše gore go ruta tlotlontšu ya geometry go kaonafatša mabokgoni a barutwana dithutong tša geometry. Nyakišišo ye e tšweleditše lenaneothuto la go dira diteko go ruteng didiritšwa tša 3-D le papetlatšhomelo ya tlotlontšu ya geometry gape le go kgothaletša mpshafatšo ya lenaneo-thuto go tsenyeletša thuto ya tlotlontšu ya geometry ka gare ga lenaneo-thuto gammogo le lelokelelo la tlotlontšu ya geometry ya barutwana go dihlopha tša mengwageng ka moka. Se e tla ba e le tlaleletšo ya tsebo go thuto ya dipalo. Thuto ye e kgothaletša dinyakišišo tša go ya pele go nyakolla mafelelo a go ruta tlotlontšu ya geometry go tiro ya, goba dipoelo tša, barutwana go thuto ya geometry go dihlopha tša mengwaga ka moka tša sekolo sa tlase.

MANTŠUHLOKWA:

Ditsela tša Geometry; go thala dibopego; ditshwantšho tša didirišwa tšeo di tiilego goba tša go se fetoge; dibopego tša 2-D, didirišwa tša 3-D; tlotlontšu ya dipalo; tlotlontšu ya geometry; tutuetšo ya thuto ya tlotlontšu; tiro goba dipoelo tša geometry; thuto ya geometry go sekolo sa tlase.

DEDICATION

This thesis is dedicated to God Almighty for giving me life, the opportunity, grace, wisdom, ability and strength to pursue and complete this study.

To my husband, Orevaoghene-Joel Goddie Ogor, who initiated the process, encouraged and supported me through it all and ensured that I completed it.

To our five lovely children: Esther, Emmanuel, Christabel, Jemimah and Israel for their love, constant encouragement and understanding.

To my late dad Mr J.E.O. Nwadiashi who was my first inspiration.

ACKNOWLEDGEMENTS

My profound gratitude goes to my supervisor Prof M. G. Ngoepe for her unique mentoring skill without which I may not have completed the programme.

My sincere thanks go to my able research assistant Seyram Constance Adjei for her dedication without which this research would have been more difficult. Thanks to Mr Frank Akasreku for his time and assistance and Mrs Beatrice Owusu-Boateng for her immense support, encouragement and prayers.

Many thanks to friends, family, and colleagues far too many to mention, I appreciate you all.
To my treasure, my husband Orevaoghene Ogor and the Orevaoghene clan, I say thank you.

Finally, I would like to express my sincere appreciation to the heads of school, teachers and primary 6 learners of the three schools used in this study. Without access to your school and your cooperation, data collection for this work would have been impossible. Thanks to you all.

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CHAPTER 1: INTRODUCTION

1.0 BACKGROUND AND OVERVIEW OF STUDY

Geometry is generally accepted as a key content area of mathematics for its connectedness to every strand in the mathematics curriculum and numerous real-life situations (Alex & Mammen, 2014; Yi, Flores & Wang, 2020). Cao (2018) maintains that geometry is one of the longest-established and key content areas of mathematics.

Geometry is the aspect of mathematics that deals with shapes and lines (Chiphambo & Feza, 2020). It also involves the study of the properties of shapes, their similarities and how they can be moved or transformed (Trinidad & Tobago Ministry of Education Primary School Syllabus Mathematics [TTMoEPSSM], 1999). The study of geometry contributes to the development of many basic foundational skills and enhances deductive reasoning, analytical reasoning, problem-solving and logical thinking skills (Armah, Cofie & Okpoti, 2018). Some aspects of geometry focus on the development and application of spatial concepts and dynamic imagery that, in turn, helps learners acquire a better mathematical perspective of the world in which we live (Alex & Mammen, 2015).

Tuluk **(**2013) maintains that the study of geometry provides a significant contribution to mathematical reasoning, critical thinking, proving, and relating interactivity and communication while helping improve problem-solving skills. Geometry is a significant field of study which helps learners develop the ability to think concisely, express thoughts in an organised way and support an argument with logical reasons (Hoffer, 1981). Andila and Musidi (2020**);** Ministry of Education of Taiwan (2003); National Council of Teachers of Mathematics (2000); and Wu & Ma (2005) agree that geometry is one of the most important concepts in mathematics.

In Ghana, Eshun (2004) and Eshun-Famiyeh (2005) reveal that mathematics has persistently been the most challenging subject in the school curriculum. This general view is reflected in learners' performance over the years. For example, a Criterion Reference Test (CRT) conducted in 1996 and 2000 showed that only 1.8% and 4.4% of primary year six learners nationwide obtained a mark of 55% respectively.

Also, the generally poor performance of Ghanaian JSS 2 learners with an average of 276 in mathematics, which was significantly lower than the international average of 467 in the third Trends in International Mathematics and Science Study (TIMSS) conducted in 2003, is another reflection of the status of mathematics teaching and learning in the country (Anamuah-Mensah & Mereku, 2005). The analysis of the Ghanaian learners' performance on the released items indicated that measurement, geometry, and algebra were the candidates' weak content areas. The mean percentage of Ghanaian learners making correct responses to the released items in measurement, algebra, and geometry were 17.3%, 13.6% and 13.4%, respectively (Anamuah-Mensah & Mereku, 2005). This indicates that geometry is the weakest of the weak content areas.

Issues regarding the difficulty in learning geometry in mathematics are well established in literature (Yi, Flores & Wang, 2020; Wu & Ma, 2006; Clements, 2003; Battista, 1999). Thus, researchers and teachers constantly search for the reasons for these challenges with the aim of developing appropriate pedagogic strategies to help overcome the difficulties (Naidoo & Kapofu, 2020). Researchers maintain that some of the problems encountered by learners in the learning of geometry include incomplete comprehension of the problem and mathematical symbols, producing proofs based on direct visual elements, lacking strategic knowledge in producing proofs etc. They further maintain that geometry instruction is often more complex than that of numerical operations or elementary algebra. As a result, to tackle the difficulties in learning geometry, they propose that it is important that geometry instructions incorporate new and tested approaches in the teaching of the concept, of which the teaching of mathematics vocabulary associated with geometry could be one (Özerem, 2012; Chazan, 1993; Healy & Hoyles, 2000).

Learning geometry may not be easy and based on interviews with several learners, the difficulty emanates from learners' inabilities in abstract thinking and analysis of properties of geometric objects (Wiska, Musdi & Yerizon, 2020). The lack of understanding in learning geometry often causes discouragement among learners, which invariably leads to poor performance (Noraini, 2009). Several factors which have been put forward to understand why geometry learning is difficult, include visualisation abilities, ineffective instruction and geometry language (Noraini, 2009, 2006; Cangelosi, 1996). There is the need to ensure a good understanding of basic concepts and the language of geometry or geometry vocabulary to provide foundations for future work, correctly interpret geometric problems and communicate ideas (Jones, 2002).

Güner and Gülten (2016) explain that the effective teaching and learning of mathematics depends on the accurate use of vocabulary. Vocabulary refers to all the words in a particular language (Hornby, 2010); therefore, geometry language is geometry vocabulary. Mathematics vocabulary refers to all the words and symbols used in the pedagogy of mathematics. It follows that geometry vocabulary refers to all the words and symbols used in the teaching and learning of geometry, and geometry vocabulary is a subset of mathematics vocabulary. Pierce and Fontaine (2009) state that a child's knowledge of mathematics vocabulary is an important indicator of how successful a child will perform in mathematics. It can be implied that a learner's knowledge of geometry vocabulary is an important indicator of how well a learner will perform in geometry. Lee and Herner-Patnode (2007) state that without an understanding of the vocabulary that is used routinely in the teaching of mathematics, learners are obstructed in their efforts to learn mathematics and geometry.

Monroe and Panchyshyn (1995) explain that because vocabulary provides access to concepts, instruction in the vocabulary of mathematics is crucial. As a result, it cannot be incidental. Additionally, the authors argue that vocabulary teaching in mathematics should be given careful attention within the school curriculum; hence, a necessity for this study.

1.1 THE RESEARCH PROBLEM

Despite consistent effort to increase the rigour of mathematics instruction through teaching standards, learners' performance in mathematics remains low and achievement gaps persist (National Assessment of Educational Progress [NAEP], 2017). According to the Ghanaian Primary School Mathematics Syllabus, geometry is classified as shape and space. It is taught at all levels in the primary school and one of the general aims of the Ghanaian primary school mathematics programme is to help learners communicate effectively using mathematical terms and symbols (Republic of Ghana Ministry of Education, Science & Sports [MoESS], 2007). Mathematical terms and symbols are mathematical vocabularies and symbols. In the context of geometry, the syllabus aims to help learners communicate effectively using geometry vocabulary. This said syllabus was in use from 2007 to 2018.

Anamuah-Mensah and Mereku (2005) revealed that the analysis of the Junior Secondary School 2 (JSS 2) Ghanaian learners' performance on the released items indicated that geometry was the weakest content area as reported in the 2003 Trends in International Mathematics and Science Study (TIMSS).

The mean percentage of Ghanaian learners who were able to provide the correct responses to the items in geometry was 13.4%. The report also revealed that Ghana's average score in geometry was the second-lowest of all the participating countries.

According to Bennin (2012), several reports (TIMSS, NEA, WAEC) indicate that there is a persistent and consistently poor performance of Ghanaian SHS, JHS and Primary School learners in the field of mathematics in general, and geometry in particular. According to her, national reports show that Ghanaian learners are performing poorly in geometry.

More reports regarding the state of learners' performance in geometry in Ghana - TIMSS (2007; 2011) and Gunhan (2014) affirm that performance in geometry continues to be the lowest of all five domains covered by the test. In addition, the West African Examination Council (WAEC) Chief Examiner's annual reports for the West African Senior School Certificate Examinations (WASSCE) from 2012 to 2015 indicated that learners were weak in problems related to 2-D shapes and 3-D objects. In addition, the report of the chief examiner for Diploma in Basic Education (DBE) End-of-Second Semester Mathematics Examination in geometry from 2012 to 2016 consistently showed lower performance revealing that learners were unable to solve problems that require the use of properties of geometrical shapes, indicating a lack of adequate knowledge in geometry and application of geometric concepts (Armah, Cofie & Okpoti, 2018).

Blessman and Myszczak also showed that one of the causes of confusion in mathematics is vocabulary. They stated that "much of the research on problems that learners encounter in mathematics courses points to the many language-based misconceptions that learners develop" (Blessman & Myszczak, 2001, p. 14)

Riccomini et al. (2015) maintain that mathematics is a content area that builds from prerequisite skills to more advanced skill. Since mathematics is a hierarchical subject, concepts taught in higher classes in schools are built on the foundations laid in the earlier years of primary education. For example, in primary 5, learners are taught to know the number of faces, edges and vertices in 3-D objects and in primary 6, they are taught to classify 3-D objects based on their number of faces, edges, and vertices (MoESS, 2007). Mastering and applying higher-order mathematics concepts requires learners to integrate and build upon series of prerequisite skills (Nelson, Pfannenstiel & Edmonds, 2019).

If learners do not understand the concept of identifying the faces, edges and vertices of these objects taught in primary 5, how will they be able to classify 3-D objects based on these properties in primary 6? It can, therefore, be argued that the under-performance of Ghanaian secondary school learners in geometry, as quoted by Bennin (2012), could be due to a lack of understanding of geometry concepts and vocabulary at the primary school level, among other factors. If learners do not understand the concept of geometry in their early years, it will be difficult for them to comprehend geometry in the upper classes, where geometry is introduced with a high level of assumption of previous knowledge.

Taking a look at the records of the researcher's primary 6 learners' performance in geometry, and the records of other primary six teachers in Ghana over the years, the researcher observed that the geometry grades of primary 6 learners were usually low compared with other concepts in mathematics such as place value, addition, subtraction, ratio and proportion, to mention a few.

This low performance of Ghanaian learners in geometry may be due to the strategies employed in the teaching of geometry in Ghanaian primary schools, among other factors. According to Özerem (2012), geometry vocabulary comprehension is an area of difficulty for many learners.

1.2 RESEARCH OBJECTIVES

The objectives of this study are:

- To investigate the strategies used in teaching geometry in primary six;
- To investigate the teachers' perceptions about geometry vocabulary teaching;
- To investigate how geometry vocabularies are taught in primary six; and
- To investigate how the teaching of geometry vocabulary influences primary six learners' performance in geometry.

1.3 RESEARCH QUESTIONS

Geometry is an important branch of mathematics about studying shapes and space, and its teaching and learning take place in all grades (Gökbulut & Ubuz, 2013). Shape and space are part of the Ghanaian mathematics syllabus from primary one to six (MoESS, 2007).

This study seeks to answer the following questions:

1. What strategies are used in the teaching of geometry in primary six in Ghanaian primary schools?
2. What are teachers' perceptions about geometry vocabulary teaching?
3. How do primary six teachers in the selected Ghanaian primary schools teach geometry vocabularies?
4. How does the teaching of geometry vocabulary influence learners' performance in geometry?

1.4 HYPOTHESES OF THE STUDY

The null hypotheses and hypotheses of the study are stated as follows:

Null Hypotheses (H_0): There is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

Hypotheses (H_1): There is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

1.5 SIGNIFICANCE OF THE STUDY

Geometry is a compulsory subject in most science career fields, such as engineering, architectural design as well as different aspects of the construction sector and notably, the geometrical skills acquired at primary and secondary school levels are vital (Chiphambo & Feza, 2020). The real-life applications of geometry through the use of shapes and construction abilities, which can be deployed in novel situations, distinguish geometry as an essential domain in mathematics (Kapofu & Kapofu, 2020). Özerem (2012) maintains that studying geometry allows learners to assess the world in which they live and provides them with the needed knowledge to excel in other areas of mathematics. Given this, it is important to ensure that learners have a good understanding of basic geometric concepts and geometry vocabulary to lay a foundation for future work, think critically about geometric problems and communicate ideas (Jones, 2002). Some of the skills required for survival in the 21st century, such as critical thinking, communication, creativity, problem-solving, collaboration, logical argument and analysis among others, are instilled through the study of geometry (Chiphambo & Feza, 2020). Analysis, interpretation of logical arguments and communication requires the use of vocabulary, and in the concept of geometry, they all require the use of geometry vocabulary.

Thompson and Rubenstein (2000) state that the language of mathematics is a vital tool for learners' learning. They, therefore, maintain that enculturation to the vocabulary phrasing and meanings of mathematical language by learners are dimensions of instruction that need specific attention.

The findings of this study confirm that geometry vocabulary teaching influences learners' performance and that geometry vocabularies are not in the selected schools. The findings also reveal some of the strategies used in the teaching of geometry in the selected schools. These findings provide information on teachers' perceptions about geometry vocabulary teaching, how geometry is taught in primary six in the selected Ghanaian primary schools, and the influence of geometry vocabulary teaching on learners' performance in geometry. The findings of this study are useful to learners, teachers, policymakers and curriculum developers for future planning of the mathematics curriculum to help improve learners' understanding and performance in geometry in Ghana, and other countries.

Finally, the study contributes significantly to the already existing knowledge on geometry vocabulary teaching and strategies for teaching geometry. In addition, the study developed a prototype lesson plan for the teaching of 3-D objects, a geometry vocabulary activity sheet, a sample assessment paper for prisms and pyramids and suggests a curricular reform to enhance the teaching of geometry in Ghana, and also generates interest in further research.

1.6 DEFINITION OF TERMS

For the purpose of this study, the keywords defined hereunder serve to establish precise meaning and clarity.

Mathematics vocabulary: This refers to all the words and symbols used in the teaching and learning of mathematics.

Geometry vocabulary: This refers to all the words and symbols used in the teaching and learning of geometry.

Learners' Performance: This refers to learners' raw scores in assigned tasks, including class exercises and tests.

1.7 ORGANISATION OF STUDY

This study consists of six chapters. Chapter 1 discusses the background to the research problem, the state of learners' performance in mathematics and geometry in Ghana, the statement of the problem, the research objectives, research questions and the significance of the study.

Chapter 2 reviews relevant literature on the teaching of geometry, importance of geometry vocabulary teaching, challenges experienced by learners in the study of geometry, difficulties encountered by teachers and pre-service teachers in the teaching of geometry, mathematics/geometry vocabulary teaching, and effective and ineffective strategies for geometry vocabulary teaching.

Chapter 3 explains the theoretical framework underpinning this study.

Chapter 4 explains the research methodology, it gives a detailed description and explanation of the research design, the research instruments and how these instruments were developed. The population sample, how the research instruments were administered, the validity and reliability of these instruments, and steps taken to analyse both the quantitative (questionnaires and the written tests) and the qualitative components (oral interviews) of this study, are also discussed in this chapter.

Chapter 5 presents the results of the study, following the processing and an in-depth analysis of the data.

Chapter 6 summarises the findings of the study and offers recommendations derived from these findings. This chapter further provides recommendations for future research and the limitations of this study, including a section for the study's contribution to knowledge.

CHAPTER 2: LITERATURE REVIEW

2.0 INTRODUCTION

The study aimed to investigate how the teaching of mathematics vocabulary, associated with geometry, influenced primary six learners' performance in geometry. The focus is on the strategies used in teaching geometry, teachers' perception about the teaching of geometry vocabulary, how geometry vocabularies are taught in the selected schools in the Accra region of Ghana, and how the teaching of geometry vocabulary influences learners' performance in geometry.

A few researchers, including Salifu, Yakubu, Ibrahim and Amidu (2020); Baah-Duodu, Osei-Buabeng, Cornelius, Hegan and Nabie (2020); Armah, Cofie and Okpoti (2018); Appiahene, Okpoku, Akweittey, Adoba and Kwarteng (2014); and Benin (2012) have carried out studies related to the teaching and learning of geometry in Ghana. However, there is no empirical study on the influence of mathematics vocabulary teaching on primary six learners' performance in geometry in the greater Accra region of Ghana, revealing a gap in the literature. The gap necessitated this study. I as a researcher relied on a few studies from Ghana and many studies across the globe for information. Relevant literature was reviewed under various headings, and the chapter ends with a chapter summary.

2.1 THE YEAR SIX LEARNER IN GHANA IN COMPARISON WITH THEIR SOUTH AFRICAN COUNTERPARTS

The academic year in Ghana starts in September and ends in August while that of South Africa runs from January through to December. A typical primary six learner in Ghana should be between 11 and 12 years old at the onset of the academic year, and this is equivalent in age to a grade 6 learner in South Africa. The comparison of the mathematics curriculum of both countries shows some similarities and differences.

Number operations in the primary 6 and the grade 6 Mathematics syllabi of Ghana and South Africa are very similar, however, there are a few differences in terms of the depth of a few specific concepts. In both countries, learners at these levels are supposed to recognise the place value of whole numbers up to 10 digits (1 billion) and 9 digits (999,999,999) respectively.

While South African grade 6 learners are expected to compare numbers up to nine digits, primary 6 learners in Ghana are expected to compare numbers up to six digits, which is the expectation for grade 5 learners in the third and fourth term in South Africa.

Similarly, while grade 6 South African learners are expected to round off numbers to the nearest 5, 10, 100 and 1,000, primary 6 learners in Ghana are expected to round off numbers to the nearest 10, 100, 1,000 and 10,000.

The geometry content for grade 6 and primary 6 learners in both syllabi also have similarities and differences. Both syllabi expect the learners at these levels to understand the properties of 2-D shapes and 3-D objects having begun from lower primary years with the introduction of the tetrahedron and other pyramids in Grade 6 in South Africa. Both curricula also expect learners at these levels to recognize and describe lines of symmetry in two-dimensional shapes; perform reflection, and translation of geometric figures and solids, sort 2-D shapes and 3-D objects using their number of faces, the shape of faces, number of vertices and edges. In addition, Ghanaian primary 6 learners are expected to sort 3-D objects with uniform cross-section. Highlighting the differences, perimeter, area and volume are captured in grade 6 in the South African syllabus while this is expected to be taught in primary 5 going by the Ghanaian Mathematics syllabus. Enlargements and reductions of 2-D shapes are to be taught in the fourth term in grade 6 in South Africa, but in Ghana, this is not taught in primary 6, it is rather taught in secondary school. Also, the primary six Ghanaian learners are expected to identify images and translation vectors, but this topic is not within the scope of grade 6 learners in South Africa. Going by this analysis, grade 6 learners in Ghana are somewhat on par with grade 6/7 learners in South Africa.

It is interesting to note that two of the specific skills outlined in the South African mathematics syllabus for basic schools are to develop the correct use of the language of mathematics and to develop number vocabulary. However, in the allocation of daily teaching time, no provision was made for the teaching of mathematics or geometry vocabulary. In the case of Ghana, the curriculum content has no mention of mathematics or geometry vocabulary as stated in the South African mathematics syllabus (MoESS, 2007; CAPS, 2012; TIMSS, 2015; NaCCA, 2019).

It is about time curriculum developers inculcate the teaching of mathematics and geometry vocabulary into the mathematics syllabus and make provision for its teaching. The fieldwork of this study was carried out when the former Ghana Mathematics syllabus was still being implemented.

2.2 A CASE FOR TEACHING GEOMETRY VOCABULARY

2.2.1 Defining vocabulary teaching

According to Susanto (2019), definitions and vocabulary play important roles in the teaching and learning of mathematics and geometry. "Vocabulary" as related to mathematics is also called terminologies or jargon. Hornby (2010) refers to vocabulary as all the words in a particular language. Vocabulary teaching involves the direct and indirect instruction of vocabulary or words. The building blocks for content understanding are words, and learners need to understand the words that express that content to communicate (O'Connell et al., 2005). Vocabulary is the knowledge of words and meanings (Honig, Diamond, Cole & Gutlohn, 2008). They explain that vocabulary understanding plays a major role in a learner's comprehension in virtually every content area, including mathematics. According to Riccomini, Smith and Hughes (2015), the teaching and learning of mathematics vocabulary is key to developing proficiency in mathematics.

Mathematics vocabulary refers to all the terms used in the teaching of mathematics. It involves the use of numerals, words and symbols that are at times interrelated and interdependent and at other times disjointed and autonomous (Adams, 2003). Monroe and Panchyshyn (1995) classified mathematics vocabularies into four distinct categories, namely technical, sub-technical, general, and symbolic. Technical mathematics vocabularies have only one meaning specific to mathematics alone; for example, integers, polygons etc. Sub-technical mathematics vocabularies have more than one meaning which varies from one content area to another, making these words difficult to conceptualise. General vocabulary includes words used in everyday life and mathematics. This group of words are so many that learners sometimes find it challenging to remember them all and apply them correctly in the mathematics classroom. Symbolic vocabulary involves the signs and symbols used in mathematics.

These are sometimes complicated and confusing for learners. The vocabulary used in mathematics is crucial in the dissemination of mathematics instruction and mathematics, as a numerical science, is best communicated through its specialised mathematics vocabulary, which is required for adequate understanding and performance of learners (Adams, 2003). Geometry is thus best communicated using geometry vocabulary.

2.2.2 The importance of geometry vocabulary teaching

There has been increased research in the area of mathematics vocabulary in recent years with an emerging number of studies indicating that mathematics vocabulary is crucial for mathematics performance, in preschool and early elementary years (Forsyth & Powell, 2017; Powell, Driver, Roberts & Fall, 2017; Powell & Nelson, 2017). Umamaheswari (2020) posit that mathematics vocabulary instruction assists learners to comprehend and understand mathematics concepts better.

Considering the key role geometry plays in mathematics, learners' ability to communicate mathematically needs to be improved to achieve the goals for learning geometry (Andila & Musdi, 2020). Many researchers argue that the use of mathematics vocabulary is essential because learners who use it effectively by way of reading, writing and comprehension of mathematical concepts understand mathematics better and, as a result, achieve in it (Güner & Gülten, 2016; Buchanan, 2007). Thompson and Rubenstein (2000) posit that for learners to read, understand and discuss mathematical ideas, they need to master mathematics vocabulary and, as such, the key component in understanding mathematics is learning the vocabulary. Learners thus benefit when teachers take time to teach the language of mathematics.

As learners learn and understand mathematics vocabulary, their understanding of mathematical concepts increases and this helps them achieve the goal for learning mathematics vocabulary, which is to help learners solve problems independently (Monroe & Orme, 2002). As this happens, learners will be able to apply these problem-solving skills outside the mathematics classroom and across the curriculum (Shields, Findlan & Portman, 2005).

A child's knowledge of mathematics vocabulary is an important indicator of how successful a child will perform in mathematics (Pierce & Fontaine, 2009). This is in agreement with Powell, Driver, Roberts and Fall (2017), who maintain that to answer questions on mathematics assessments and understand communication between teacher and student, learners must develop an understanding of mathematics vocabulary. It can be implied that a learner's knowledge of mathematics vocabulary associated with geometry is an important indicator of how well a learner will perform in geometry. Without an understanding of the vocabulary that is used routinely in mathematics instruction, learners are handicapped in their efforts to learn mathematics in general, and geometry in particular (Lee & Herner-Patnode, 2007).

Teaching and learning mathematics successfully is directly linked to the accurate use of mathematics vocabulary and, as mathematics progresses cumulatively, the use of mathematics vocabulary is vital in the process. As a result, the incorrect use of mathematics vocabulary right from primary school will plague learners' understanding of mathematics and correct usage of the vocabulary as they progress from primary school through secondary to tertiary level (Aydin & Yesilyurt, 2007; Ferrari-Luigi, 2004; Pimm, 1987). In this respect, teachers must use accurate mathematics vocabulary right from the onset of mathematics in school (Güner & Gülten, 2016; Raiker, 2002).

The study of geometry assists learners to enhance their critical thinking skills, daily problem-solving ability and subsequently prepare for further studies (Musdi & Yerizon, 2020). The study and understanding of geometrical concepts provide a veritable tool of visualisation for arithmetical algebraic and statistical concepts implying that geometry is a vital component of mathematics (Noraini, 2009). The National Council of Teachers of Mathematics in the United States of America (USA) indicates that geometry is one of the five "content standards" of school mathematics, which aims at developing spatial reasoning, problem-solving skills, and communication (Sellke, 1999).

Reading research also supports a stronger relationship between vocabulary knowledge and comprehension. The connection between mathematics vocabulary knowledge and mathematics comprehension is critical because, without knowledge of mathematics vocabulary, learners may not understand complex concepts and, as a result, some learners may not be able to perform more advanced tasks (Shields, Findlan & Portman, 2005). In the context of geometry, if learners do not understand geometry vocabulary, they may not be able to perform advanced tasks in geometry.

Learners' failure to understand mathematics vocabulary may be showcased in several ways. For example, a lack of response or incorrect response to questions during lessons, inability to do assigned mathematics tasks, and poor performance in mathematics tests (DfEE, 2000). Learners' incorrect responses or lack of responses to questions may be due to a lack of understanding of the given instruction, for example, "ring…", not being familiar with the mathematics vocabulary or confused as to the meaning of the mathematics vocabulary as some mathematics words have different meanings in everyday English. For example, "odd" and "table" to mention a few (DfEE, 2000).

Effective mathematics problem-solving in every content area of mathematics, including geometry, is usually predicated on the astute knowledge and understanding of key mathematical terms and symbols. Adequate knowledge of key mathematical terms and symbols are immediately relevant in solving word problems and performance-based tasks, which are sometimes challenging for some learners, who normally find mathematics easy to cope with (Honig, Diamond, Cole & Gutlohn, 2008). Valley (2019) maintain that regular execution of mathematics word problems in the classroom significantly improved the use and understanding of English mathematics vocabulary establishing the strong relationship between them.

The ability to communicate in mathematics is essential in taking standardised tests, and the teaching of mathematics vocabulary enhances this skill. To answer questions in a standardised test requires the learner to understand the question, which also requires the learner to understand the extensive mathematics vocabularies used. Learners who understand the mathematics vocabularies connected to various concepts may have a better chance of answering questions correctly compared to learners who do not understand what the vocabularies mean (Nilsen & Nilsen, 2003; Flanagan, 2009).

As learners extend their mathematics vocabulary, the more sensible and understandable the subject should become, and they may be better able to apply mathematics appropriately in other disciplines. As the learners derive and understand more mathematical concepts, they should be more willing to learn more mathematics. Learners who find themselves proficient in mathematics are usually more confident and often see themselves as problem-solvers; develop understanding and learn procedures through hard work, and they see that the need to become mathematically proficient is worthwhile according to Donovan and Bransford (2004).

The use of geometry vocabulary in the teaching of geometry is vital (Toptas, 2015). This is displayed in the fact that geometry requires the use of vocabulary more than other mathematics concepts (Ashfield & Prestage, 2006). Geometry vocabularies are important for the effective teaching of geometry in the learning environment and beyond. The lack of adequate vocabulary and proficiency reduces the efficacy of the tutoring process in geometry (Webb & Feza, 2005). According to Bloom, "The most basic type of knowledge in any particular field are its terminology" (Bloom, 1956, p. 63). Terminology refers to the body of terms used with a particular technical application in a particular field, subject of study or profession (Hornby, 2010). The learning of geometry vocabulary should be a prerequisite for the acquisition of geometry knowledge at all levels of geometry. However, learners lack the appropriate vocabulary to express the distinguishing properties of a figure or the appropriate theorem to use in a geometry problem (Renne, 2004; Webb & Feza, 2005).

Flanagen (2009) and Vacca and Vacca (2002, p. 160) believe that "vocabulary is as unique to a content area as fingerprints are to a human being." This goes to say that vocabulary instruction should be carried out in every subject and content area of the various subjects that learners learn in school. This is to enable learners to understand, appreciate, interpret, analyse and apply the concepts in the different fields of study, authenticating the need to teach geometry vocabulary when teaching geometry.

Mathematics vocabulary teaching enables learners to comprehend and understand mathematical concepts and researchers maintain that the development and accomplishment of mathematics skills in learners lie in establishing a proper understanding of mathematics vocabulary in the classroom (Bhuvaneswari & Umamaheswari, 2020). This implies that learners are unlikely to grow to their full potential in mathematics if they do not have the opportunity and experience of learning the meaning of the vocabulary used in the teaching and learning process. As a result of this handicap, learners may be unable to use higher-level thinking (Monroe & Orme, 2010), which is an important skill in geometry. Clements and Samara (2011) posit that geometric thinking skills are indispensable skills needed for the development of higher-order thinking (Hassan, Abdullah & Ismail, 2020). This implies that learners may be unable to develop higher-level thinking skills adequately without the proper understanding of geometry vocabulary.

While teaching learners at the basic school level, teachers are advised to regularly identify applicable means to adequately define terms and, if required, use informal language, or use concept-based vocabulary and grammar (Ball, Lubienski & Mewborn, 2001).

The issues at stake are to discover the definitions of concepts, which are right for the basic school level, and if it would be in place to give all learners the same definitions. Would it be proper for teachers to teach directly from the textbooks, or reproduce the textbook contents in their simple terms? How would a primary six teacher explain the concept of a rectangle to the learners so they would understand which shapes are not called rectangles, and the reasons for that classification? In a fourth-grade class that Ball teaches, some learners believed that a cube was a rectangle because one of the faces of the box resembled a rectangle and in an age of computer graphics, they translated rectangle to box intuitively. In this instance, it was observed that learners needed definitions that were learner-friendly and usable with a reliance on vocabularies and ideas they were already familiar with. Further, teachers are therefore required to know more than the definitions they have learned at the tertiary level of studies (Ball, 2000).

The central nature of mathematics vocabulary, and the requirement for adequate mathematics vocabulary in teaching geometry, is of obvious concern. The limited or lack of proper mathematics vocabulary associated with geometry is one of the reasons for the learner's misconceptions in geometry (Oberdorf & Taylor-Cox, 1999). It is crucial that vocabulary be taught and made available to learners early in their geometry course to remediate learner's imprecise use of geometry vocabulary (Hoffer, 1981).

The power of language in assisting learners to make distinctive classifications was emphasised by Gray, Pinto, Pitta and Tall (1999). They indicate that through verbal discussions, instruction and construction, the learner may begin to see hierarchies with one idea classified within another so that a square is a rectangle, which is also a quadrilateral. This indicates that the language used by a teacher is crucial in the development of understanding about 2-D shapes and their relations to other shapes, implying that the idea of teaching geometry vocabulary is of key importance if learners are to fully understand the concept of geometry. The influence of the teaching of mathematics vocabulary associated with geometry on the performance of Ghanaian primary six learners in geometry in selected primary schools in Accra is the focus of this study.

2.3. GEOMETRY IN THE GHANAIAN PRIMARY SCHOOL MATHEMATICS CURRICULUM

Geometry is a key segment of the mathematics curriculum in most countries, including Ghana (MoESS, 2007) and Hassan, Abdullah and Ismail (2020) affirm that geometry is a foundational topic and a vital element of the mathematics curriculum. Learners' general mathematical competencies in areas such as measurement, algebra, calculus, and trigonometry have been closely linked to their geometric understanding (Russell, 2014). This makes geometry a very important component of the mathematics syllabus, as geometric representations can be used to help learners make sense of other areas of mathematics, such as fractions and multiplication in arithmetic, the relationships between the graphs of functions of both two and three variables, and graphical representations of data in statistics (Jones, 2002).

Teaching geometry in schools is required to develop learners' logical thinking abilities. This indicates that the learning of geometry assists learners to think coherently and develop a better understanding of mathematics (Hoffer, 1981; Suydam, 1985; French, 2004). Geometry is essential and a prerequisite for study in areas such as geology, biology, chemistry, drawing, art, astronomy and physics, geometric skills are important and widely used in real life by architects, computer experts, engineers, various aspects of construction work and many other professionals (Wiska, Musdi & Yerizon, 2020). The teaching and understanding of geometry vocabulary would allow learners to appreciate a wider range of subject areas in and outside school (Sherard, 1981).

The former Ghana mathematics syllabus, which was in use when this study started until July 2018, classified geometry under shape and space, and the geometry content for primary six learners in that syllabus included: to classify solid shapes according to given criteria i.e. prisms and pyramids; identify solids whose cross-sections have the same shape and same/different sizes; identify nets of cubes, cuboids and cylinders and to make models using the nets; draw and label the parts of a circle (MoESS, 2007). However, in 2019, the National Council for Curriculum and Assessment (NaCCA) in collaboration with the Ghana Ministry of Education rolled out a new Mathematics syllabus in August 2019. The new syllabus highlighted Geometry and Measurement as one of the four main strands alongside Number, Algebra and Data. The geometry and measurement strand is further stratified into lines and shapes, measurement and geometrical reasoning. Going by this curriculum, primary six learners are expected to study and understand prisms and their cross-sections, construct rectangular and triangular prisms from their nets, describe the position of objects in space using the cardinal points and perform a single transformation (reflection and translation) on 2D shapes in a plain (NaCCA, 2019). The new curriculum is said to set out the learning areas that need to be taught, how they should be taught and how they should be assessed. However, there is no provision for mathematics or geometry vocabulary teaching in the entire curriculum, and this needs to be addressed.

Various reasons contribute to learners' poor performance in the geometry of which lack of geometry vocabulary teaching could be fundamental. Some of the other reasons include poor teaching methods (West African Examination Council WAEC, 2007), which are basically due to the teacher-centred model of teaching (Armah, Cofie & Okpoti, 2018; Ampiah, Akyeampong & Leliveld, 2004). Mereku (2010) maintains that some teaching staff of mathematics departments have poor styles of disseminating knowledge to their learners.

He claims that they essentially put across mathematical concepts, principles, and algorithms in a casual and non-committal manner, making learners passive and fearful observers during learning. This is in agreement with De Villers (2012) who explained that most geometry teachers gave learners ready-made definitions, classifications, proofs, etc. to memorise and reproduce during assignments or assessments. The required level of discussion and interactions, and the opportunity to engage in group work, is usually absent. This approach, where the teacher is the centre of the learning process, leads to situations where learners are alienated from the actual learning process, and they judge mathematics to be a difficult and unfriendly subject, leading to poor performance (Mereku, 2010). With little or no room for discussions, learners do not have the chance to express themselves and engage with geometry vocabulary, an activity which should enhance learners' proficiency.

According to Lijuan and Wenting (2018), in the process of mathematics teaching, learners are required to memorise. This mathematics tutors' teacher-focused method of making learners memorise facts rather than explore to discover for themselves usually arouses learners' dislike for mathematics and breeds a negative attitude in learners regarding the acquisition of knowledge in mathematics and geometry. This leads to a perception that mathematics is too abstract and difficult to cope with and is reflected in the reduced level of success and problem-solving skills in mathematics and, particularly, in geometry (Eshun, 2004; Boaler, 2008; Lockhart, 2009).

The International Mathematics and Science Study (TIMSS, 2003) states that at the Junior High School level, the learners' performance in geometry was lower than other aspects of mathematics such as data analysis, number, algebra and measurement (Anamuah-Mensah, Mereku & Asabere-Ameyaw, 2004). The performance of the Ghanaian learners in geometry was much lower in comparison with other aspects of mathematics as tested and stated in (TIMSS, 2007; 2011; Anamuah-Mensash, Mereku & Ghartey-Ampiah, 2008; Gunhan, 2014; Mullis, Martin & Foy, 2008).

The WAEC Chief Examiner's report of the 2005 WAEC examination indicates that there is also an observed high failure rate in mathematics and geometry at the Senior High Schools (SHS) in Ghana. The WAEC (2005-2010) reports reveal that there are blatant learner learning deficiencies in the areas of geometry and theorems. The Mathematics Association of Ghana (MAG) annual conference in 2011 stipulated that the failure rate among the learners was due to their inability to understand the concepts of mensuration, logarithm and geometry (Etsey, 2011). This inability to understand the concept of geometry could be due to a lack of understanding of geometry vocabulary. This study, among other things, is set to discover whether primary six teachers in the selected primary schools teach geometry vocabularies or not.

To address learners' poor performance in geometry in Ghana, Bennin (2012) carried out a study exploring the Effect of Interactive Geometry Software (IGS) on senior high school learners' understanding of, and motivation to learn geometry. The findings indicated no significant difference in the conceptual understanding between the Control and Experimental groups in the pre-test. However, in the post-test, the findings indicated that the Experimental group had a mean score of 76.61, while the Control group achieved a mean score of 58.06. The t-test results revealed that there was a significant difference in the conceptual understanding of geometry in favour of the Experimental group at P=0.001. The findings also showed that the learners in the experimental group were highly motivated to learn geometry because they enjoyed the IGS lessons. It further revealed that the use of IGS supported learner-centred learning in numerous ways; the lessons were activity-based, interactive in nature, and learners worked in groups and learned collaboratively through discussions. The discussions required learners to use mathematics vocabulary associated with geometry to explain their reasoning and understanding about the concept, which may be the reason for the significant difference in favour of the experimental group.

Bennin (2012) maintains that to draw the full benefits of geometry in the mathematics curriculum, classroom instructions should be aimed at enhancing learners' geometric thinking. Improving learners' geometric thinking levels is one of the major aims of mathematics education. This is because geometric thinking is an important tool in many scientific, technical and occupational areas such as architecture, computer animation, engineering, piloting, physics, maritime, land surveying, and robotics to mention a few (Bennin, 2012). This suggests that geometry vocabulary teaching should be incorporated into the mathematics syllabus not just in Ghana, but in mathematics curricular across countries to empower learners to perform well in mathematics and other disciplines.

Geometry, in the Ghanaian Mathematics curriculum, includes the study of the properties of solids and plain shapes with particular reference to the relationship between them. The specific areas include shape and space, angles, rigid motion, enlargements and similarities, properties of polygons and geometric constructions (MoESS, 2007).

According to the Curriculum Research and Development Division (2007), learners should be taught to learn as follows:

- **Plain shapes:** draw plain shapes and identify their parts, relating connecting faces, edges and vertices of solid objects, nets of solids.
- **Angles:** measure and draw angles, types of angles, triangles, angles between lines.
- **Properties of quadrilaterals.**
- **Rigid motion:** congruent figures, translation by vector, reflection, rotation, symmetrical shapes and objects, rotational symmetry.
- **Polygons:** types of triangles, polygons.

By this compilation, the Ghanaian curriculum undertakes the two and three-dimension spatial sense as a fundamental component of the primary grade study and assessment of geometry. At the Junior High School stage, the curriculum goes beyond simple identification of geometric shapes or using procedures to apply spatial visualisation skills to understand relationships. This is an inclusion of both informal and formal construction of geometric figures. These focus on the geometric principle behind the constructions. Learners are acquainted with simple identification of 2-D shapes such as triangles, circles, rectangles and identifying line segments and angles. However, the researcher observed that the curriculum does not make specific reference to the teaching of geometry vocabulary to guarantee learners' understanding of their meanings and not simply committing them to memory. In most cases, learners memorise mathematics vocabulary associated with geometry without a clue as to what the words mean.

2.4 CHALLENGES EXPERIENCED BY LEARNERS IN THE STUDY OF GEOMETRY

Many learners have difficulties learning geometry concepts (Yi, Flores & Wang, 2020) and Alex and Mammen (2012) maintain that concerns with difficulties in learning geometry are not new; they can be traced back several decades internationally (Usiskin 1982; Fuys et al., 1988; Gutierrez, Jaime & Fortuny, 1991; Clements & Battista, 1992). Findings from these studies indicate that many learners, in both middle and high schools, encounter difficulties and show poor performance in geometry as a result of some of the reasons discussed below.

2.4.1 Lack of appropriate Teaching Aids

Several researchers concluded that the difficulties in geometry prompted much research by educators in the Soviet Union from 1930-1950 (Clements & Battista, 1992; Alex & Mammen, 2012). Those studies aimed to find the source of the problems that learners encounter in geometry. One of the sources of the problems was assumed to be the inability of learners to have adequate spatial orientation, which could be enhanced through the use of teaching aids and manipulative materials in the classroom. The study further enumerates that learners must understand that geometric shapes are defined by their properties and not their orientations in space. Armah, Cofie and Okpoti (2018) maintain that integrating hands-on activities and investigations with manipulative concrete materials in the Van Hiele phase-based instruction enhances learners' creativity and assists them to build concrete concepts while exploring geometric concepts. However, most learners in Ghana do not have access to adequate teaching aids and manipulatives. There is a need to provide learners with the necessary materials and activities which will enable them to discover the properties of simple geometric shapes in different orientations. Makhubele (2014) advocates that learners should be allowed to investigate and discover mathematics facts for themselves. Suitable instructional guidance from teachers would encourage learners to formulate their definitions of various shapes and discover facts. Despite this argument, the lack of teaching aids and manipulatives cannot solely account for the difficulties that learners encounter in geometry, especially when the issue of appropriate geometry vocabulary teaching has not been considered.

2.4.2 Inappropriate Teaching Methods

The teaching method is also a major cause for concern as more often than not, most teachers in Ghana teach geometry by rote instead of rational learning (Salifu, Yakubu, Ibrahim & Amidu, 2020). Rote learning encourages learners to memorise concepts and formulas rather than explore to discover the intrinsic properties of the concepts (Structchens, Harris & Martin, 2001). This method of learning geometry limits and restricts learners and does not support the development of learners' reasoning abilities (Salifu, Yakubu, Ibrahim & Amidu, 2020). Due to this teaching style, learners find geometry a challenging discipline, and this consequently leads to poor performance in geometry and mathematics.

2.4.3 The case of Ghanaian Learners

In Ghana, The Chief Examiner's Report (CER) on the Basic Education Certificate Examination (BECE) for 2001, 2003, 2005 and 2006 revealed that the candidates had a very shallow knowledge in geometry and the use of geometric concepts. The 'Trends in International Mathematics and Science Study' (TIMSS) report (2003), an international survey in mathematics and science achievements report, indicates low performances by Ghanaian Junior High School 2 (JHS 2) learners who participated in the exams. The nation of Ghana was positioned 45th out of 46 countries. In analysing the results, it was observed that learners performed worse in geometry than other subject areas such as algebra, data, number and measurements (Anamuah-Mensah, Mereku & Asabre-Ameyaw, 2004).

Table 2.1 Mean percentages of Ghanaian learners obtaining correct responses

Content Domain	Range	Mean
Number	0.2 – 47.2	26.6
Algebra	0.6 – 29.0	13.6
Measurement	0.5 – 39.0	17.3
Geometry	0.1 – 26.0	13.4
Data	2.4 – 48.5	27.0

[*Source: Anamuah-Mensah, Mereku & Asabre- Ameyaw, (2004)]*

It was indicated in the report that less than one per cent of basic school learners could perform the required geometric tasks and questions. This is a strong indication that geometry is a big challenge for most Ghanaian learners. The contributing factors for the poor performance are not far-fetched, since the Ghanaian mathematics syllabus does not make provision for the teaching of mathematics and geometry vocabulary during geometry lessons.

In 2010, one hundred and eighty-eight (188) learners from two senior high secondary schools were involved in Baffoe and Mereku's study on the Van Hiele levels of understanding of learners entering senior high school in Ghana. The Van Hiele Geometry Test adapted from the 'Cognitive Development and Achievement in Secondary School Geometry Test' items and an aptitude test was given to the learners at entry-level into the senior high school and in the fourth week of school. The results showed that 59% of the learners attained Van Hiele level 1. Out of 59%, 11% reached level 2 and only 1% reached level 3 by the theory. This reveals that the Van Hiele level of understanding of (over 90%) Ghanaian learners is lower than that of their colleagues in other countries before entering senior high school (Baffoe & Mereku, 2010). This is also an indication that the Van Hiele level of understanding of Ghanaian primary learners is extremely low if only 13% of the learners who have completed primary school reached level 3. The pedagogy of geometry in Ghanaian primary schools needs an overhaul to adequately address the issue of learners' abysmal performance in geometry.

To support the above claim are the findings of Asemani, Asiedu-Addo and Oppong (2017) who investigated the geometric thinking level of senior high school learners in Ghana. Two hundred (200) final year senior high school learners selected from three municipalities in the Central Region participated in the study. The results showed that 33%, 22.5%, 1.5%, and 0.5% of the learners reached Van Hiele's levels 1, 2, 3 and 4 respectively, indicating that 45.5% of the selected secondary school final year learners in Ghana were on level 0 of Van Hiele Geometric thinking.

The Van Hiele Model (1986), which partly frames this study, was formulated to substantially improve the performance of mathematics educators and learners in geometry. The model revealed that the development of learners thought patterns in geometry were not predicated on age or biological maturity, rather it is a consequence of the form and effectiveness of instruction received by the learners (Jones & Ding, 2006). Since most of the instruction in geometry does not include mathematics and geometry vocabulary, this creates a gap in the learners' learning experience.

This position of the Van Hiele model further elucidates the current state of the teaching and learning of geometry in Ghanaian primary schools.

2.5 THE STATE OF TEACHERS' AND PRE-SERVICE TEACHERS' GEOMETRY KNOWLEDGE

A teacher's content knowledge forms the basis of the teacher's instructional practices in the classroom (Capraro & Capraro, 2018). According to Grossman (1995), teachers who have an excellent understanding of their subject areas far better teach their disciplines than teachers whose knowledge base in the subject is low. In addition, the quality of the facts and information available to teachers, and their knowledge, determines the quality of planning and instruction for learners (Munby, Russell & Martin, 2001; Hill, Schilling & Ball, 2003). These authors agree that the quality of the teacher's knowledge in mathematics has a significant impact on how the knowledge is accessed and deployed during a teaching session. The effective teaching and learning of geometry are predicated on the teacher's understanding of geometry, and the methods and activities employed by the teacher to teach it to the learners effectively. This prescribes that the teachers should have an ardent knowledge of the subject area of geometry to ensure that the learners are properly tutored and grounded in the discipline (Jones, 2000). This implies that teachers require a proper understanding of geometry vocabulary to adequately impact geometry knowledge to their learners.

A teacher's ability to have a well-grounded understanding of the required subject area provides the required platform for teachers to present the concepts in their subject area in a manner that allows learners to learn and participate fully in the process. Research by Sunzuma and Maharaj (2019) in Zimbabwe found that 47.5% of in-service teachers were not adequately prepared to teach geometry in secondary school due to insufficient knowledge in the topic and, as a result, they skipped the teaching of some aspects of geometry (Niyukuri, Nzotungicimpaye & Ntahomvukiye, 2020). In situations where the teachers are limited in their understanding and conceptualisation of their subject area, the teaching and learning sessions are superficial, not interactive and sometimes boring as the teacher is mainly trying to present facts. In the context of geometry, due to teachers' shallow knowledge of geometry, the teacher is unable to engage learners in meaningful in-depth discussions that could enhance learners' geometric understanding and generate possible interest in geometry. These teachers tend to present geometry to learners as an abstract content and mere statement of facts, which is a fallacy. This is in agreement with Asiedu and Yidana, who maintain that teachers' level of understanding contributes directly to the outcome of the teaching and learning process (Brophy & Alleman, 1991; Asiedu & Yidana, 2000).

Contemporary research concerning the improvement and development of teacher's proficiency in mathematics have indicated that there were three major components of a teacher's knowledge base for optimal productivity, namely mathematics content knowledge, pedagogical knowledge and pedagogical content knowledge (Chinnappan & Lawson, 2005). According to their research, mathematics content knowledge includes materials and information which are mathematical concepts, rules and associated procedures for problem-solving. The level of understanding of teachers of these three components in the field of geometry is predicated on their understanding of the mathematics vocabulary associated with geometry. Content knowledge consists of knowledge about the subject, while pedagogical knowledge is the knowledge of the processes involved in teaching. Pedagogical knowledge, according to Shulman, is a special kind of knowledge which is employed, or used, by teachers to teach learners in a manner that promotes a deep understanding of the subject area (Shulman, 1986). In consonance with Shulman, pedagogy in the teaching of geometry should include the teaching of mathematics and geometry vocabulary.

Chinnappan and Lawson (2005) undertook a study on the standard and quality of the Ghanaian basic school pre-service teachers' Geometric Knowledge for Teaching (GKT) and found the proficiency of Ghanaian teachers in geometry crucial to proper learning by learners at all levels in Ghanaian schools. Though geometry is important for the full functional understanding of mathematics and its allied disciplines, it is noted that some mathematics educators are not fully proficient in the field of geometry (Swafford, Jones & Thorton, 1997) despite Fletcher's argument that the strength of an educational institution is determined by the level of proficiency and knowledge possessed by the teachers (Fletcher, 2001).

The Colleges of Education in Ghana teach geometry as one of the areas of emphasis and curriculum taught to pre-service teachers at school. The contents of geometry taught to learners at the Colleges of Education in Ghana include lines, angles, polygons, geometrical constructions, 2-Dimensional shapes and 3-Dimensional solids, circle theorems, geometrical transformation and coordinate geometry (Armah, Cofie & Okpoti, 2017). However, the Chief Examiner's report of the course titled 'Methods of teaching junior high school Mathematics' in the period 2005-2007, revealed that the learner teachers were unable to fully comprehend some aspects of geometry. During the 2006 session, most learners could not understand the term "rotational symmetry". The learners mainly used wrong geometrical figures to answer the question. Furthermore, in 2007, learners could not represent the angle at the correct point, and some of them had difficulty differentiating between pyramids and prisms. This could be linked to inadequate comprehension of geometry vocabulary.

Salifu (2018) investigated the Van Hiele level of geometric thinking among 298 mathematics pre-service teachers from five Mathematics and Science Colleges of Education in three Northern Regions of Ghana. The results recorded the following percentages; 50.3%, 23.5%, 14.8%, 9.1%, 2.3% and 0%

for Van Hiele 's levels 0, 1, 2, 3, 4 and 5 respectively, indicating that 88.56% of the pre-service teachers attained levels 0, 1 and 2. Salifu concluded that only 11.4% of the pre-service teachers had the required content knowledge to teach geometry in basic school and recommended that Colleges of Education tutors adapt Van Hiele model of geometric thinking when teaching geometry lessons (Salifu, Yakubu, Ibrahim & Amidu, 2020; Salifu, 2018).

Armah, Cofie and Okpoti (2018) investigated the effect of Van Hiele Phase-based Instruction (VHPI) on Ghanaian pre-service teachers geometric thinking in terms of the Van Hiele levels. Van Hiele Geometry Test (VHGT) was administered to 75 pre-service teachers as both pre-test and post-test. Pre-service teachers in the control group were taught two-dimensional geometry using the conventional instruction method while pre-service teachers in the experimental group were taught two-dimensional geometry using the VHPI. The results showed improved post-VHGT scores for both groups of preservice teachers. However, the pre-service teachers in the experimental group achieved better levels of geometric thinking as compared to the ones in the control group. In addition, more of the pre-service teachers in the experimental group attained levels 3 and 4 as against levels 0, 1 and 2 in the control group indicating that the VHPI is capable of improving learners' geometry levels more than the conventional approach.

Outside Ghana, Yi, Flores and Wang (2020) examined the influence of Van Hiele theory-based instructional activities on 111 elementary pre-service teachers' geometry knowledge for teaching 2-D shapes. The results showed that Van Hiele theory-based instruction is effective in improving three strands of learners' geometry knowledge for teaching, namely geometry content knowledge, knowledge of learners' Van Hiele levels, and knowledge of geometry instructional activities. The study recommends that elementary pre-service teachers be suitably prepared in advance with geometry knowledge for teaching before they embark on teaching.

Fujita and Jones (2007) in a study that sought to discover the abilities of pre-service undergraduate teachers in Scotland, mentioned that when the trainee teachers were asked to define and classify quadrilaterals, which is geometry subject knowledge, the majority of them had a poor understanding of this area of mathematics. The trainee teachers did not have a clear conceptual appreciation of the hierarchical relationship between quadrilaterals. It became clear that after two or more years of study, their understanding of the concept was still shallow, and had not improved in any significant measure.

The research suggested that the lack of appropriate understanding of background knowledge of quadrilateral was borne out of certain deficiencies during their high school education. These deficiencies include an inability to comprehend and understand geometry and mathematics vocabulary. This is further supported by Pickreign (2007) who conducted a study on the properties and relationship among parallelograms. In the process, forty pre-service teachers, who were taking a course on pre-methods mathematics courses for elementary education, were asked to provide written responses to descriptions of the terms; rectangle and rhombus. Out of the forty people that took part in the survey, only nine respondents were able to adequately describe the rectangle, and one respondent was able to describe the rhombus. This shortfall indicates that the trainee teachers would be found wanting when faced with the responsibility of adequately explaining the concepts to their learners. This is an obvious deficiency in the understanding of geometry vocabulary.

The National Council of Teachers of Mathematics (NCTM, 2000, p. 16) teaching principle indicates that "effective mathematics teaching requires understanding what learners know and need to learn, and then challenging and supporting them to learn them well." This indicates that what learners know and what they need to learn further is a derivative of adequate content knowledge at the level, or above the level, of what is expected of the learners. This immediately paints a scenario where the trainee teachers may not have the capacity to adequately tutor their learners in geometry since some of the teachers themselves lack adequate understanding of geometry and geometry vocabulary.

Baturo and Nason (1996) studied the level of understanding of subject matter knowledge display of first-year education learners in the aspect of area measurement. The study focused on the learner teacher's substantive knowledge about the nature and discourse of mathematics, mathematics in society, and on the teacher's disposition towards mathematics. The researchers observed that first-year teacher education learners had a shortfall in the area of measurement. This shortfall became an impediment in their comprehension of probable multiple representations, varied activities and learning styles for their learners. This would be a barrier to proper learning by their learners in other areas of mathematics. Area measurement is the foundation of volume measurement and other aspects of geometry.

Mayberry (1983) studied the five learning levels of the Van Hiele model with 19 pre-service elementary teachers, 13 of whom had studied high school geometry. Tasks were designed to involve the first four levels using seven common geometric concepts, namely squares, right triangles, isosceles triangles, circles, parallel lines, similarity and congruence. The result showed that “70% of the response patterns of the learners who had taken high school geometry were below level 3. The response patterns suggest that these pre-service teachers were not at the proper level to understand formal geometry and that the instruction they had received had not brought them to level 3” (Mayberry, 1983, p. 68). Furthermore, the study showed that before deductive geometry instruction, learners may not benefit from instruction in formal geometry, if they have not had experiences of reasoning leading to the development of level 2 thought processes.

Sixty-seven participants provided the relevant data for Mason and Schell’s research on prospective elementary school teachers’ geometry knowledge. It was discovered that 38% of the basic school pre-service teachers had a proficiency level below level 4, and 8 % of the teachers could barely make the lowest level, which is recognition. Further analysis raised an issue of serious concern as the results revealed that between 30% and 51% of the pre-service teachers were below level 3 (Mason & Schell 1988) implying that some of the pre-service teachers do not have the needed knowledge to teach elementary school geometry. This immediately raises concerns in Ghana. Would these results have any similarity or bearing on the Ghana situation? Could this be one of the reasons for the low level of performance of basic and high school learners in mathematics and geometry in Ghana?

The study of Swafford, Jones and Thorton (1997) was carried out on pre-service middle school teachers and some similarities can be derived from the study for application to the Ghanaian situation. This study elucidates the effects of assisting the teachers to understand geometry better and to equip them with the methods of teaching geometry. The study undertook a survey, measured the content and the Van Hiele level of understanding of the teachers at the commencement of a four-week tutoring program and at the end of the programme. Positive significant changes were observed to the extent that it became obvious that if teachers are properly prepared, they would be able to teach the learners properly and appropriately to ensure higher performances by the learners. However, the study failed to mention whether the teaching of mathematics and geometry vocabulary was part of the tuition that the pre-service teachers were given during the four-week tutoring.

The study of Chinnapan, Nason and Lawson (1996) sought to discover the pedagogical and content knowledge of trigonometry and various aspects of plain geometry among pre-service teachers. The

study highlighted the fact that pre-service teachers do not have adequate knowledge in the areas of trigonometry and geometry. However, the study failed to highlight the possible cause, or causes, of this lack of adequate knowledge by pre-service teachers. This discovery exposes the fact that most primary and secondary school mathematics teachers may not have enough subject-matter knowledge and pedagogical content knowledge of geometry required to teach the various topics of geometry in an acceptable and applicable manner. This immediately prescribes continuous professional development and content-specific training for mathematics educators throughout their professional life as mathematics tutors. In addition, the content-specific training should include the teaching of geometry vocabulary to adequately equip the pre-service teachers to accomplish their task as teachers.
The mathematical knowledge required for teaching and learning extends beyond mere mathematical skills.

It is required that teachers must be able to do the following:

- Assist learners with explanations for common rules and procedures in mathematics.
- Carry out an extensive analysis of learner's solutions and explanations.
- Employ the use of pictures or diagrams to represent mathematical terms, concepts, and procedures to learners.

This leads to an inherent need for teachers to be knowledgeable in mathematical representation, mathematics vocabulary, error analysis of learners' work, and the questions that arise from the use of mathematical rules and procedures (Ball, Bass, Sleep & Thames, 2005).

Mooney and Jones (2002) examined graduate primary school trainee teachers' knowledge and understanding of spatial concepts. The focus of the study was to discover the form of geometry knowledge required for the effective teaching of spatial concepts. The audit of trainee teachers' knowledge and confidence, with assessments of teaching competencies provided the required data for the study. The analysis of the data showed that the teacher trainees understanding of geometry was rather poor. Their knowledge of geometry ranked much lower than their knowledge of other subject areas, such as measurements, numbers, and algebra. Certain topics were clearly out of their scope in geometry, such as the nets of solids, and they were not capable of solving simple problems like calculating the surface area of a triangular prism. According to Brophy (1991), this could affect the teaching of those content areas. However, the study failed to indicate whether the teachers could find the area of rectangles and triangles. Assuming most teachers could not find the surface area of a triangular prism, then the trainees' poor performance might immediately be pinned down to a lack of understanding of vocabulary. Surface area is a mathematics vocabulary associated with geometry. If the teachers understood the meaning of 'surface area', they would have been able to solve the problem.

Güner and Gülten (2016) examined pre-service primary mathematics teachers' skills of using mathematics vocabulary (verbal and symbolic) in the context of quadrilaterals. The results revealed that although the pre-service teachers were positive regarding using mathematics vocabulary, they succeeded in using verbal and symbolic languages separately but failed to use both the verbal and symbolic vocabulary together. They represented the geometric shapes symbolically and failed to explain the properties of the figures verbally and vice versa, indicating that the pre-service teachers poorly used geometry vocabulary.

According to Kapofu and Kapofu (2020), several interventions have been employed by researchers in an attempt to dispel some phobia for mathematics, and generate learners' interest as well as enhance their performance in geometry.

Hassan, Abdullah and Ismail (2020) carried out a systematic review of research on the effects of integrative interventions with Van Hiele phase on learners' geometric thinking. The research consolidated the findings from existing research to determine the effect size of the various approaches used to investigate the levels of geometric thinking skills between 1998-2019.

The review showed that the classification of interventions employed were technology and manipulatives respectively and that the interventions were effective for both small and large effect sizes. The review further revealed that Geometer SketchUp was the most commonly used approach and that Technology-based intervention combined with the Van Hiele phase recorded a larger effect size.

2.6 STRATEGIES USED IN THE TEACHING OF GEOMETRY

Strategies used in the teaching of geometry are ways or methods used in the teaching of geometry, including the use of pictures, drawing of diagrams of shapes, cutting of plain shapes on paper, making of solid shapes using their nets, use of software, and hands-on activities such as the use of manipulatives etc. The use of these strategies impacts on learners' understanding of geometry in one way or the other. However, only a few literature reports address specific strategies used in the teaching of geometry.

Chiphambo and Feza (2020) explored learners' views on how polygon pieces and dictionary mediate learning of geometry among nine grade 8 learners. The study found that polygon pieces with mathematics dictionary helped learners with geometric conceptualisation through cutting, constructing and measuring of angles and line segments. It also enhanced learners' learning of geometry. In addition, the study found that the dictionary increased learners' geometry vocabulary by transferring informal vocabulary and recommended that mathematics teachers integrate polygon pieces assisted by mathematics dictionary in the teaching and learning of mathematics.

Albaladejo, Garcia and Codina (2015) conducted a study in two cycles, with four classes, at a secondary school on the influence of Dynamic Geometric Systems (GeoGebra) on learners' mathematical competencies development. They found that exposing learners to the use of tools and diagrams as well as software in studying geometry supported learners in achieving basic to medium levels in competencies related to reasoning, argumentation and communication. This indicated that using this software as a strategy for teaching geometry influenced learners' performance positively.

Suydam, Marilyn and Higgins (1977) reviewed and synthesised research conducted in grades K - 8 on activity-based teaching approaches, including studies on the use of manipulative materials. They reported that based on the synthesis, learners had a higher chance of achieving better in mathematics when mathematics lessons inculcated manipulative materials. In addition, they explained that a combination of both manipulative materials and pictorial representations is highly effective with children at all achievement, ability, and socioeconomic levels. Based on this report, it can be concluded that the use of pictures of shapes and geometric manipulative materials in the teaching of geometry is an effective strategy for teaching geometry.

Daher and Jaber (2010) interviewed two groups of elementary school geometry teachers to find out about their conception of geometry, the need to teach geometry in the elementary school, and their teaching methods. Also, the study probed what they thought about the success or failure of their teaching methods and what geometric skills they deemed necessary for elementary school learners.

As part of their findings, the two groups of elementary teachers emphasised the importance of tools in the teaching of geometry. They maintain that the success and failure of teaching methods are greatly dependent on tools and suggested that researchers and designers of geometry instruction should increase the repertoire of tools and resources available to teachers for the teaching of elementary school geometry.

Oviawe and Uddin (2020) examined the effects of audio-visual resources as an instructional strategy for improving learners' academic achievement and interest in geometry. One hundred and twenty-three senior secondary school 2 learners participated in the study. The results revealed that the use of audio-visual resources as an instructional strategy in technical colleges had a positive impact on learners' interest and achievement in geometry.

Sharma (2018) carried out a study in an urban community college with transitional mathematics classes to investigate the effect of instructional videos and real-life activities on the mathematical achievement and the attitude of developmental learners towards learning mathematics through instructional videos and real-life activities. Four mathematics classes used in the study received various combinations of instructional videos, real-life activities, and traditional teaching while studying basic concepts such as decimal place value, percentages, and fractions. The results showed that overall, the classes receiving consistent exposure to videos and real-life activities had greater mathematics achievement than classes receiving only some of the special instructional treatments. The study also found that there was no difference in the mathematics performance of learners taught by real-life mathematics activity assisted instruction and learners taught by instructional video. Finally, the study found that although there was no significant difference between the mathematical attitudes of learners taught by the instructional video and real-life activity assisted instruction and the attitudes of learners taught by the traditional methods, the percentage of learners who believed that real-life activities helped them learn mathematics with greater understanding increased by 15% from pre-test to post-test. Although this study was not carried out in the field of geometry, it gave credence to the use of videos and real-life activities as a valuable strategy for teaching mathematics.

2.7 RESEARCH ON THE INFLUENCE OF MATHEMATICS VOCABULARY TEACHING ON LEARNERS' PERFORMANCE IN MATHEMATICS

Mathematics contains numerous vocabularies; therefore, mathematics lessons should be developed around them. Mathematics vocabularies are the words and symbols used in mathematics, some of which are specific to mathematics and according to Pierce and Fontaine, the depth and breadth of a child's mathematical vocabulary will influence the child's success in mathematics (Pierce & Fontaine, 2009; Wearden, 2011). Bhuvaneswari and Umamaheswari (2020) posit that teaching mathematics vocabulary assists learners to comprehend and understand mathematical concepts better.

Gharet (2007) in his study carried out among 3rd graders in a general education class in an urban city tried to find out whether incorporating mathematics vocabulary into the mathematics curriculum improved learners' comprehension of mathematical concepts. He incorporated mathematics vocabulary teaching into his maths lessons through direct instruction. The results of his research showed that the incorporation of mathematics vocabulary into the mathematics curriculum increased learners' comprehension of mathematical concepts as well as their test scores.

Lewellen (2008) in his study of 8th graders' mathematics, investigated the influence of vocabulary instruction on learners' understanding of mathematical concepts. Some of the vocabularies involved in his study were product, denominator, cylinder, area, circle, and polygon. He discovered that knowing the meaning of the vocabulary did play a major role in the learners' understanding of the daily lessons and the ability to take tests. Understanding the vocabulary and concepts allowed the learners to be successful in their daily assignments, chapter tests, and standardised achievement tests. He used different vocabulary teaching strategies such as creative strategy, the strategy of four boxes and game strategy. Using the creative strategy, each learner drew a diagram or a picture of the vocabulary or term to define the term. The strategy of four boxes involved learners drawing four boxes, writing a vocabulary in one box, writing the definition of the vocabulary in the second box, writing a sentence with the word in the third box and in the fourth box drawing a picture to go with the vocabulary. The game strategy was a vocabulary bingo game. He read the definition of one of the vocabulary terms, and the learners would find it on their cards. Using these different strategies in his mathematics vocabulary instruction, he discovered that using different vocabulary teaching strategies enhanced equity in his classroom among diverse learners. The knowledge of the mathematics vocabulary increased his learners' confidence levels, which, in turn, increased their daily and test scores. The study investigated the influence of vocabulary instruction on learners' understanding of mathematics concepts in general; it did not indicate the specific mathematics concepts investigated. However, this study will focus on investigating the influence of teaching mathematics vocabulary associated with geometry on learners' performance in geometry.

Ninety-eight first-grade learners with mathematics difficulty were randomly assigned to addition tutoring with an embedded vocabulary component, addition tutoring without the embedded vocabulary component, or business-as-usual control group by Powell and Driver during their study on the influence of mathematics vocabulary instruction embedded within addition tutoring for first-grade learners with mathematics difficulty. At post-test, learners who received addition tutoring without vocabulary showed greater gains than learners in the control group on addition fluency. On a measure of mathematics vocabulary, learners in the active tutoring conditions achieved improved performance on mathematics vocabulary over learners in the control group. Results indicate that exposure to addition tutoring with or without an embedded vocabulary component positively improves mathematics vocabulary performance (Powell & Driver, 2014).

Blessman and Myszczak (2001) carried out action research for improving learners' comprehension of mathematical vocabulary among two classes of fifth-grade learners in Illinois. The problem of poor mathematical vocabulary was documented through teacher and learner surveys and questionnaires, teacher observation of learners' daily work, and learner vocabulary checklists. A review of solution strategies that experts in the field proposed mathematics vocabulary acquisition and mastery combined with the analysis of the results. This led to the introduction of interventions such as math journals, visual aids, learner-created math dictionaries, graphic organisers, and children's literature to introduce and reinforce mathematical concepts and written explanations of open-ended word problems. The analysis of the findings revealed that as a result of the interventions, the learners' exhibited an increase in comprehension and use of mathematical vocabulary. It also improved their performance.

Brethouwer (2008) in her research focused on the use of specific methods of vocabulary instruction and learners' use of precise mathematical vocabulary in writing and speaking among her sixth-grade learners. The strategies she used for vocabulary teaching included activities such as partner games, a word wall, a learners' dictionary, word cards, small group activities and the use of manipulative. She wanted to see what effects these methods or strategies would have on learners' performance. The research findings suggested that learners, who struggled with the retention of mathematical knowledge, had inadequate mathematical language skills. The research also revealed that learners who had a sound knowledge of mathematics vocabulary and were engaged in the specific use of content language were more successful. Final analysis of the research indicated that learners believed that the use of specific mathematics vocabulary helped them to be more successful, and they made moderate progress in their performance on assessments. Therefore, there is the need to investigate whether primary school learners' performance in geometry will improve when they have a sound knowledge of geometry vocabulary and engage in the use of it.

Noriani (2009) in his study of the Impact of Using Geometers' Sketchpad on Malaysian Learners' Achievement and Van Hiele Geometric Thinking, found that effective learning occurred as learners actively experienced the objects of study in appropriate contexts of geometric thinking, and as they engaged in discussion and reflection using the geometry vocabulary. Mathematics directions and problems are compressed into a few words and the use of symbols further reduces the number of words in a mathematics problem, making each symbol or word important. This is a significant reason which makes vocabulary instruction in mathematics vital if learners are to become proficient in the subject (Prindle, 2003).

It is fundamental that learners understand the meanings of mathematics vocabulary words and can use them in the proper context. If they are going to become capable users of mathematics, they need to comprehend the principles behind the techniques, and knowing the vocabulary will help learners improve their skills in mathematics (Tobias, 1987). Research has also shown that learners ought to understand mathematics vocabulary if they were to master mathematics content and apply it in future situations (Thompson & Rubenstein, 2000). This implies that teaching vocabulary in the mathematics content area in general and geometry in particular is a critical element of effective instruction, and effective vocabulary instruction must provide more than simple definitions.

Learners need more than just surface knowledge of words and teaching vocabulary words solely as definitions do not assist learners in comprehending these words when they find them in texts. Learners must be actively engaged in building background knowledge using key content-specific vocabularies (Stahl & Fairbanks, 1986). Learners should be actively engaged in using mathematics vocabulary associated with geometry to build background knowledge in geometry and to discuss and explore the concept to ensure an understanding of the meaning of the words.

Most studies on mathematics vocabulary considered mathematics vocabulary as a single construct concerning one mathematics outcome. However, Peng and Lin (2019) investigated how different types of mathematics vocabulary highlighted in the curriculum were related to different mathematics outcomes among learners in 4th grade in China. Two hundred and thirty-seven learners were involved in the study and data regarding mathematics vocabulary, general vocabulary, mathematics (calculation and word problems) and cognitive skills (IQ, working memory, and processing speed) were collected. The results showed that after controlling for general vocabulary, IQ, working memory and processing speed, mathematics vocabulary contributed to learners' mathematics performance. However, the effects of mathematics vocabulary varied by different types, revealing that mathematics vocabulary made a unique contribution to problem-solving but not to calculations. Mathematics vocabularies related to geometry and measurement were more important to word problems than vocabulary related to numerical calculations. The study showed that measurement and geometry vocabulary partially explained the relationship between word problems while general vocabulary and IQ explained the relationship between word problems and working memory. The findings indicate that mathematics vocabulary may not be a unitary construct, but is made up of subtypes that relate to different mathematics outcomes among fourth-graders.

2.8 WHY TEACHERS DO NOT TEACH GEOMETRY VOCABULARY

Richek (2006) maintains that some teachers do not think of vocabulary instruction as a very productive practice. This could be because the teachers themselves were not taught mathematics vocabulary and were also not trained to teach it. The prevalent practice for learning vocabulary when they were in school was to get a vocabulary list, look up the meaning of the words, memorise the meaning and, occasionally, use the words to make sentences. This was the extent of vocabulary instruction they received as learners, and this was mostly in a language, not in mathematics. In addition, during their training, they were not trained to teach mathematics vocabulary. There are no empirical studies to show that trainee mathematics teachers were trained to teach mathematics vocabulary associated with geometry as part of the mathematics instruction they received. If the teachers lack an understanding of mathematics vocabulary associated with geometry, how are they expected to teach it?

Time constraint could also be another major reason why teachers do not focus on the teaching of mathematics vocabulary. Many teachers do not think that the time available for teaching and assessing mathematics is adequate, let alone adding on the teaching of mathematics word meanings. In addition, the teaching of mathematics and geometry vocabulary is not indicated in the Ghana primary school mathematics curriculum. How and when are the teachers supposed to teach it? These are issues that need to be addressed in the contest of geometry teaching as highlighted in the Ghana basic school mathematics syllabus.

Vocabulary, according to Nilsen and Nilsen (2003), is an extremely difficult skill to teach and that can also account for why teachers do not teach it. Teachers themselves need to investigate effective methods of mathematics vocabulary teaching before they can successfully teach mathematics and geometry vocabulary, and this is lacking in practice. In vocabulary development, three obstacles were identified by Stahl and Nagy (2006) namely, the fact that English was a foreign language to some of the learners, even if they came from English-speaking homes. Secondly, the number of words that children needed to learn. Finally, the fact that understanding a word is much more than memorising the definition.

Roberts and Truxaw (2013) explain that mathematics vocabulary may be more difficult to learn than other academic vocabularies because mathematics definitions are often saturated with technical vocabulary symbols and diagrams. In addition, many mathematical concepts can be represented in multiple ways; the words have multiple meanings e.g., volume meaning amount of space and volume meaning noise level. The multiple meanings of various mathematics vocabulary are a big challenge for learners. For example, the difference between 11 and 5 means 11 take away 5, which gives 6; while the difference in temperature between a city with a temperature of minus 11 degrees Celsius and another city with a temperature of 5 degrees Celsius is 11 plus 5, which gives 16. Learners often struggle with such problems, and sometimes teachers find it difficult to explain the difference between how to solve the two problems.

Monroe and Orme (2002) argue that the limited use of geometry vocabulary outside the mathematics classroom makes the teaching difficult. The vocabulary used in mathematics is usually limited to the mathematics classroom, and learners often do not have background knowledge of these words. They maintain that because teachers do not pay attention to meaningful vocabulary teaching in mathematics in general, and in geometry, learners are not likely to learn mathematics vocabulary associated with geometry in the classroom either. If mathematics learners are to learn and understand mathematics vocabulary associated with geometry, then it is the responsibility of the mathematics teacher to teach the in-depth meaning of the vocabulary without any assumptions that learners will encounter those words in the same context anywhere else.

The Pennsylvania Department of Education indicates that by the time learners reach sixth grade (11-12 years), they should understand 43 mathematical terms and concepts from the previous year (Shields, Portman and Findlan, 2005). Most mathematics words are abstract. As a result, they are difficult to understand and, in addition, many of them are used for more than one concept, even in mathematics.

An example is the word median, which, in one sense, means the middle term of a numerical data arranged in order. In another sense, median means the line drawn from the vertex to the midpoint on the opposite side. Teachers need to help learners make the connection that although both words do relate to the middle, they are quite different. The teachers' assistance in making such connections is vital (Rubenstein & Thompson, 2002). With all these issues surrounding learners' mathematics and geometry vocabulary, the mathematics teacher plays a key role in learners' acquisition and correct use of mathematics and geometry vocabulary. The teachers' role includes teaching the vocabularies adequately and ensuring that the vocabularies are used frequently in the mathematics and geometry class as learners may not encounter those words anywhere else.

2.9 SOME INEFFECTIVE METHODS OF TEACHING MATHEMATICS VOCABULARY

Having understood from literature some of the importance of mathematics and geometry vocabulary instruction, it is necessary to consider some ineffective ways of teaching mathematics vocabulary.

2.9.1 Dictionary search

Most teachers give their learners a mathematics vocabulary list to look up the definitions of the words and take a test after a few days. This strategy of mathematics vocabulary instruction is grossly ineffective as learners simply commit the meaning of the words to memory for the test, after which they forget completely in most cases. Learning words by just finding their dictionary meaning only gives learners a little idea about the word. For learners to effectively learn word definition from a dictionary, the learner must know something about the word (Shields, Findlan & Portman, 2005) and teachers should give learners activities beyond dictionary search.

2.9.2 Assessment by multiple choice

Teachers' assessment of learners' understanding of mathematics vocabulary through multiple choice questions is another ineffective method of teaching mathematics vocabulary. According to Nilsen and Nilsen (2003), when the correct response to a vocabulary question is in a set comprised of one correct response, and three incorrect responses, as learners spend time reading and re-reading the right and wrong responses, he or she becomes confused and often may change their original correct knowledge about a word.

2.9.3 Memory device

The use of memory devices to teach vocabulary is ineffective because they are based on the use of a pun or riddle. The actual meaning of the word is not being used and as a result, the learners are not learning the meaning of the vocabulary or concept; instead, they are learning the pun (Nilsen & Nilsen, 2003).

2.9.4 Wrong definitions

Teaching learners the wrong definition for words is another ineffective strategy for teaching mathematics vocabulary. Elementary school teachers are to blame sometimes for some incorrect use of mathematics vocabulary associated with geometry. For example, most elementary mathematics teachers refer to a rhombus as a diamond, and the learners learn it as such. Also, they use the term oval instead of an ellipse. According to Tracy (1994), if vocabulary is used correctly from the start, learners will remember the words for many years. Thus, once learners learn the incorrect meaning of words; to unlearn what they have learnt and re-learn the correct meaning of the vocabulary becomes an uphill task. It is therefore mandatory that mathematics teachers use mathematics vocabulary correctly from the onset to inculcate in their learners the appropriate use of the vocabulary.

2.10 SOME EFFECTIVE STRATEGIES FOR THE TEACHING OF MATHEMATICS VOCABULARY

2.10.1 The Study of Kucan et al.

Learners need to develop an awareness of the impact of the words that they speak, use and hear. There is power in the words used in communication, especially in learning (Carter & Dean, 2006; Graves, 2009). Mathematics has a language all on its own, better referred to as “math lingo” (Hersh, 1997).

The teaching of mathematics vocabulary is an important aspect of mathematics that requires time and commitment on the part of the teachers, as stated by Kucan et al. (2006). The same can be said about the teaching of mathematics vocabulary associated with geometry. They carried out a study with high school teachers at Allengheny High School to study the effects of vocabulary instruction. Four hundred and twelve high school learners participated in the study, entitled “A Professional Development Initiative for Developing Approaches to Vocabulary Instruction with Secondary Mathematics, Art, Science and English Teachers.” The research revealed ten crucial areas that the teachers highlighted as being both necessary and required to teach vocabulary to learners. They are:

1) Teacher commitment to vocabulary development in terms of planning and classic time.
2) Willingness to experiment with a variety of instructional approaches and to adapt those approaches as needed.
3) Setting learning goals in terms of developing rich representations of word meanings, as well as an understanding of how words work.
4) Facilitating learner access to multiple sources of information.
5) Providing support and encouragement for learners to discover connections among words, including forms of words and related words.
6) Giving learners opportunities to create multiple representations of words.
7) Highlighting cross-curricular connections.
8) Sustaining commitment to activity-based approaches.
9) Acknowledging the social dimension of classrooms by providing chances for learners to work together, and to present and perform with, and for their peers.
10) Developing interesting assessments involving multiple contexts for focusing on word meanings and features of words (Kucan et al., 2006, p.10).

They explain that these ten strategies are effective in the teaching of mathematics and geometry vocabulary.

2.10.2 The Study of Flanagan

Flanagan (2009) claims that there are four main principles of effective vocabulary instruction. Firstly, teachers should use varied instructional techniques to teach mathematics vocabulary as some learners may be left out if the teacher sticks to only one method. In addition, the use of only one method in the teaching of mathematics and geometry vocabulary makes it very boring for the learners. Secondly, teachers should engage their learners during mathematics vocabulary instruction as this will deepen learners' involvement and, in turn, their level of comprehension. The third principle is for teachers to ensure that learners have ample opportunity to interact with the vocabulary and to communicate mathematically by way of discussions and explaining their methods and reasoning using mathematics vocabulary. Learners should also have the chance to see how the vocabularies are used in questioning, so they are not confused during tests. The last and most important principle, according to Shields, Findlan and Portman (2005), is for teachers to help learners connect words to prior knowledge and concepts. If teachers help learners make a connection between vocabulary and concepts they already know, the learners are more likely to remember the new information (Furner, Yahya & Duffy, 2005; Lee & Hermer-Patnode, 2007; Shields, Findlan & Portman, 2005).

2.10.3 Writing Methods

There are specific strategies for teaching mathematical vocabulary. One major strategy is keeping journals or logs. This involves the creation of on-going records of the activities of learners in the mathematics class, which presents a chronological compilation of their learning experiences (Fabricus, 2012; Bromley, 2007; Burns, 2004). Burns (2004, p. 31) recommends that teachers should help learners concentrate on their journal writing using four methods:

1) Apply the required mathematical vocabularies to indicate what the whole class did on the given day.
2) Apply the required mathematical vocabulary to indicate what the individual learner learned in class on the given day.
3) Indicate what the individual learner was uncertain, or wondering, about.
4) Indicate all that was easy to do in class, or what was difficult for the individual learner in the class on the given day.

Using these journal prompts would be the required help needed for learners to learn the mathematical vocabulary and to use them appropriately.

There is substantial value in having learners write and communicate about mathematics. This is because writing is a much higher activity than just verbal or oral communication (Burton & Morgan, 2000). Teachers can evaluate their learner's conceptual understanding by encouraging learners to express their understanding of mathematics in written form (Wood, Williams & McNeal, 2006). Thompson and Rubenstein (2000) prescribe using this method in combination with class discussions, which are concluded with journal writing. They conclude that these journal entry methods assist learners to address questionable areas of understanding in mathematics. By using the journal method, the learners can peer-edit each other's writing. Checking a classmate's journal for clarity and validity requires a deeper level of thinking than writing for oneself (Burns, 2004).

The strategy where learners fold their paper in half vertically down the middle, solve the problem on the left side and explain their understanding on the right side of the paper helps learners develop mathematical communication (Anderson & Little, 2004; Auman, 2008). Thompson and Rubenstein

(2000) maintain that, at a glance, this allows the learner to see and appreciate both the computational and conceptual aspects of mathematics on one sheet of paper. Other possible avenues of helping learners understand mathematics are by using mathematical terms from newsprint, periodicals, graphs, symbols from the media and by allowing learners to accurately summarise what they understand from what they have read.

2.10.4 Concept Building before Vocabulary

The learning of mathematics should, at first, be initiated by the learning of concepts before linking up the appropriate vocabulary to the concept. In support of this position, Thompson and Rubenstein (2000) enumerated an example where a teacher would require their learners to identify several quadrilaterals and then differentiate them into categories with two pairs of parallel sides. As soon as the learners appropriately identify them, then the name parallelogram would be attached to the category or set. Learners can then be taken through further understanding of the concept by undertaking lessons on how to spell the terms. They would also be required to say and write the words correctly. The classroom experience of the learner should provide an opportunity for the learner to understand the concepts adequately through discussions and feedback from the learners (Manouchehri, 2007).

2.10.5 Oral Strategy

The idea of repetition and constant recall of mathematics vocabulary is found to be very helpful to learners in their attempt to learn new mathematics words and concepts (Marzano, Pinkering & Pollock, 2001). They advocate that for proper learning and understanding, learners must own the mathematics vocabulary associated with geometry to use it effectively, which will lead to fluency. The regular and continuous use of new mathematics vocabulary, while engaging in mathematics problem-solving, allows the learner the opportunity to become fully abreast with the concepts, and to ‘maths talk’. The teachers are expected to listen to the use of mathematics vocabulary by their learners and make corrections where necessary (Thompson & Rubenstein, 2000). It would be extremely beneficial to learners if they are allowed to discuss geometry using geometry vocabulary while the teacher listens and makes corrections where necessary.

2.10.6 Teaching Individual Words

Teaching learners the meaning and applications of individual words is a veritable means of increasing and improving vocabulary (Network, 2006). The method of having learners understand the concept before vocabulary definitions are provided is deemed an appropriate method of helping learners understand mathematical concepts. This is in agreement with Thompson and Rubenstein (2000); this method can be used to teach mathematics vocabulary associated with geometry. An example of how to teach individual words can be used in a situation where learners have to sort and differentiate two-dimensional shapes and 3-D objects into various groups as they deem fit. At this point, the learners in realising that they need to label the various groups would receive assistance from their teachers. This allows the learners to understand the concept before labelling (Network, 2006).

2.10.7 Vocabulary Review

Teachers are taught the principle of 10-24-7 in Quantum Learning for Teachers (Network, 2006). This is a sequence that locks vocabulary into learners' brains and transfers it from short-term to long-term memory. The 10 stands for reviewing new vocabulary within 10 minutes of learning it. The 24 stands for a quick review of the vocabulary 24 hours after the initial teaching, and the number 7 refers to a review again within seven days following introduction. The learning and appropriate use of new vocabulary involve regular reviewing, implying that teachers should use the new vocabulary in subsequent lessons. In adopting this method to teaching geometry vocabulary, the constant reviewing of the vocabulary is highly recommended to support mastery of mathematics and geometry vocabulary.

2.10.8 Word Banks to Assist Mathematics Vocabulary Learning

The teacher may want to establish word banks on the walls and notice board as constant reminders and review. Various mathematical vocabulary words, under specific units of study, would be hung on the walls of the classrooms, and new words should be added as soon as they are used. Regular use of new words would increase the understanding and comprehension of the mathematics vocabulary (Bromley, 2007; Burns, 2004; Furner & Berman, 2005). Teachers should employ this strategy to teach mathematics vocabulary associated with geometry.

2.10.9 Virtual Field Trips and Mathematical Software for Mathematics Vocabulary Learning

The use of the internet and numerous computer software programmes have provided an ingenious means of teaching and learning the varying levels of mathematical concepts. Mathematics educators can organise Internet trips to exotic and scientific destinations and have access to information from important institutions, such as NASA and United Nations Organisations, to use in mathematics classes.

Hawgent dynamic mathematics software is a dynamic mathematics learning media designed to make mathematical problems in geometry and algebra easier to understand and solve and at the same time interesting and enjoyable (Wijaya, Ying, Chotima & Bernard, 2020).

According to Furner and Berman (2005), there are numerous mathematics websites and mathematical software in operation to assist varying levels of individuals understand mathematics adequately. Milovanovic, Obradovic and Milajic (2013) maintain that there are several studies on the use of software tools in teaching geometry such as GeoGebra and Geometers' Sketchpad. Bulut (2011) advocates that the use of white or black boards in the teaching of geometry in the classroom be replaced with GeoGebra and this is supported by Zengin, Furkan and Kutluca (2012).

The Geometers Sketch pad is another example of one such software that helps learners learn and see geometric shapes that are more accurately drawn and surely drawn faster than the teacher drawing them on the board while labelling. This software grants learners the ability to manipulate the shapes and discover what various shapes have in common. For example, what the square has in common with a rhombus.

This software also gives learners access to discover the differences as well as similarities of shapes such as equilateral triangles, and then configure the shapes and keep the characteristics of the shapes as they alter the dimensions. In addition, learners are able to comprehend the measurements of angles and the sides quickly as they manipulate and change the size of the figures making learners active participants rather than being passive in their learning of geometry and the vocabularies involved. The question is what happens to learners in underprivileged communities, especially in Ghana for example, where there are no computers in most schools? Schools in these localities have neither the resources nor the expertise to expose their learners to this innovative way of learning geometry and the mathematics vocabulary associated with it.

2.10.10 The Use of Graphic Organisers

Graphic organisers are visual elements used to indicate clusters of ideas or concepts in the form of words, phrases or sentences (McLaughlin & Overturf, 2013). A graphic organiser in its basic form is created when a learner draws a concept or word in the middle of a piece of paper or a screen and adds related information and words to the concept, leading to a graphical representation of the knowledge (Burdur, 2019). Graphic organisers are usually set up the way the human brain organises information, and they are effective in helping learners learn vocabulary in informational text. The use of a graphic organiser will achieve better results if it is teacher-facilitated, but learner-driven (Monroe, 1998). The teacher should organise the learners into groups to create graphic organisers (Lucas & Goerss, 2007; Monroe, 1998; Vacca & Vacca, 2002).

In any case, the teacher instructing using a graphic organiser should be mindful of what he/she wants learners to achieve by creating the organiser. The learners should understand that there must be a connection between the mathematics vocabulary and the concepts on the organiser and prior mathematics vocabulary, words and concepts. Graphic organisers serve as retrieval cues for information and facilitate higher-level thinking (Monroe, 1998). However, one of the limitations of the use of graphic organisers results from the fact that before learners can successfully create a graphic organiser, they must have some background knowledge of a concept, without which learners will be at a total loss as to where to begin (Monroe & Orme, 2002).

2.10.11 Playing Vocabulary Games

Learners enjoy playing games and feel no pressure to learn when doing so without realising that a great deal of learning is taking place in the process. Shields, Findlan and Portman (2005) affirm that vocabulary games engage learners in repeated encounters with words. In addition, interactive visual and tactile experience with a game of words provides the variety and repeated practice results in vocabulary acquisition. A large variety of games are available for learners to play and learn while having fun. The games range from card games to board games, bingo, and fake-out, to mention but a few. Most games that people play can be modified to be played in the mathematics classroom. Games such as Charades and Pictionary can be adapted and played in the mathematics classroom. To do this effectively, the teacher should create a word bank of mathematics vocabulary, and play the game by the rules (Allen, 1999; Shields, Findlan & Portman, 2005). This should be adapted for teaching geometry vocabulary.

Most learners who are visual learners benefit immensely from card games. In addition to this, games such as Go Fish, Rummy, Concentration and Old Maid can be modified into mathematical vocabulary games by the teacher with the help of the learners if and where necessary. With Go Fish, Concentration and Old Maid, the teacher could ask learners to match mathematics vocabulary associated with geometry to the correct word meaning. With Rummy, the teacher could ask learners to collect words from the same concept (Rubenstein & Thompson, 2002). In the case of teaching geometry vocabulary, teachers could ask learners to collect words from geometry.

When playing Bingo, the definition of geometry vocabulary should be written out on a card for easy checking and to eliminate bias while the learners arrange the vocabulary words into a blank grid. The teacher then reads the definition of the words while the learners identify or match. Learners often enjoy playing this game and a learner can only win a prize if he or she knows the meaning of the vocabularies involved (Stahl & Nagy, 2006). Winning a prize should be enough motivation for learners to learn the meaning of the vocabulary.

Fake-Out has both positive and negative effects. Learners are put into groups by ability, sex or preference. Each group gets a different set of mathematics vocabulary. They look up the meaning of each word and create a fake-out vocabulary card. This fake-out card has a list of possible choices, and the point is to try and stump the other teams (Stahl & Nagy, 2006). The merit of this game is that learners are thinking about the correct meaning of the words. However, each group of learners can only have an in-depth study of a few words, which is a demerit of the game.

Ideally, the number of words being used should increase over time with both card games and board games. This will allow learners to continue to revisit past vocabulary words whilst learning the new mathematics words being encountered (Shields, Findlan & Portman, 2005; Rubenstein & Thompson, 2002). Shields, Findlan and Portman (2005); Monroe and Panchyshyn (1995); Furner, Yahya and Duffy (2005); Harmon, Hedrick and Wood (2005) agree that giving learners repeated exposure to experience and practise with vocabulary and concepts is another essential aspect of effective mathematics language instruction. This is the intended goal of playing vocabulary games.

Teachers can also create crossword puzzles with mathematics and geometry vocabulary, which they want the learners to learn or consolidate. However, the success of this method of vocabulary instruction is yet to be proven by research.

The depth and breadth of a child's mathematical vocabulary are more likely than ever to influence a child's success in mathematics. Yet few elementary school teachers bring effective mathematics vocabulary instruction into their mathematics lessons. To support elementary school teachers in mathematics vocabulary instruction, Pierce and Fontaine (2009) reviewed best practices in vocabulary instruction. They concluded that elementary school teachers ought to identify math-specific words and ambiguous, multiple-meaning words with mathematics denotations, such as net, plain, similar, odd and so on. Then design lessons that provide learner-friendly definitions and offer opportunities for deep processing of word meanings. They claimed that it would help learners understand math concepts better. It means that learners should be exposed to learner-friendly definitions of mathematics vocabulary associated with geometry, which will encourage deep processing of word meanings and provide extended opportunities to encounter geometry vocabularies. However, the question is that, to what extent would this exposure to geometry vocabularies influence learner's performance in geometry?

The methods of teaching mathematics vocabulary to learners adequately would involve, as suggested above, building concepts initially, oral methods, writing methods, teaching individual words, engaging in vocabulary review, creation of word banks, engaging in virtual field trips and using mathematical software, the rich presentation of words meanings, the use of graphic organisers and playing maths vocabulary games. The methods of teaching mathematics vocabulary, as enumerated by the studies, indicate that the teaching of mathematics vocabulary influences the performance of learners in the general aspects of mathematics. This study intended to investigate the actual influence of mathematics vocabulary teaching on year six learners' performance in geometry in the selected schools in the Accra region of Ghana.

2.11. CHAPTER SUMMARY

Firstly, this section described the relationship between the year-six learner in Ghana and their South African counterparts before relevant literature was reviewed under ten different headings. The definitions of vocabulary, mathematics and geometry vocabulary, and the importance of mathematics and geometry vocabulary teaching were discussed under a case for teaching geometry vocabulary. Next, geometry in the Ghanaian primary curriculum, challenges experienced by learners in the study of geometry, and the state of teachers' and pre-service teachers' geometry knowledge were discussed. It became evident from the literature reviewed that most Ghanaian pre-service mathematics teachers were not eligible to teach geometry in the basic school as only 11% of the pre-service teachers attained levels 2 and 3 of Van Hiele geometric thinking required to teach geometry in basic school (Salifu, Yakubu, Ibrahim & Amidu, 2020; Salifu, 2018). Further review of the literature regarding strategies used in the teaching of geometry was discussed together with various studies on the influence of mathematics vocabulary teaching on learners' performance in geometry alongside reasons why teachers did not teach geometry vocabulary. The chapter concluded with discussions on some effective and ineffective methods of teaching mathematics vocabulary.

CHAPTER 3: THEORETICAL FRAMEWORK

3.0 INTRODUCTION

The Van Hiele Theory of geometrical thinking and the Constructivist Theory of learning frame this study. These theories were used as lenses to explore how the teaching of geometry vocabulary influenced learners' performance in geometry. This chapter discusses these theories under various headings paying attention to the content of geometry and mathematics and geometry vocabulary teaching.

3.1 THE VAN HIELE MODEL

3.1.1 Background

Pierre van Hiele and Dina van Hiele-Geldof were a couple involved in research and mathematics education. As a result of the frustrations they experienced in the teaching and learning of geometry, in 1984, they propounded a theory and developed a model of geometric thinking (Armah et al., 2018; Armah et al., 2017; Salifu, 2018).

Initially, the Van Hiele model highlighted five major levels for the geometric thinking process from levels 0-4. However, Alex and Mammen (2016) and Howse and Howse (2015) carried out studies and added another level, making room for a sixth level known as the pre-recognition level for learners who may not be able to attain Van Hiele's level 1 (Salifu, Yakubu, Ibrahim & Amidu, 2020). The six levels of geometric thinking are Pre-recognition, Visualisation, Analysis, Informal deduction, Deduction, and Rigor. These levels, according to the theory, are sequential and hierarchical (Hoffer, 1981). The model postulates that if learners are taught at a higher level on the Van Hiele level than they are proficient in, or ready to perform in, such learners may not be able to attain the level of success required for further study in geometry (Yi, Flores & Wang, 2020). This can also be extended to other subjects and topics that depend on a good working knowledge of geometry.

The various levels of understanding of geometry as enumerated by Van Hiele are the clear indicators of the levels of appreciation of geometric principles by learners. The levels that Van Hiele postulated were the distinct levels of understanding that could be the consequence of the teaching and learning of mathematics vocabulary associated with geometry.

3.1.2 Van Hiele Level 0 – Pre-cognition

At Level 0 (pre-cognition), learners can only identify shapes if presented to them in a particular manner. According to Knight (2006, p. 4), "A learner at level 0 can identify a figure such as a square by the four sides that have the same length, and the four corners, only if one side is horizontal in the learner's line of sight. Should the figure be rotated such that the sides appear to be angled, then the learner is unable to recognise the figure such as a square, whereas learners at level 1 can identify this rotated figure as a square."

3.1.3 Van Hiele Level 1 – Visualization/Recognition

Level 1 is referred to as recognition or visualisation (Alex & Mammen, 2015; Usiskin, 1982). Learners at this level can learn the names of figures and recognise shapes by their physical appearances, but not by their individual parts or properties. As early as this stage, mathematics vocabulary becomes crucial. The learners are known to learn geometry vocabulary by learning the names of the shapes, yet they do not have a clear understanding of the concepts. Learners at level 1 can identify figures such as squares, rhombi, rectangles, and parallelogram. The difference, however, is that they cannot identify squares as special case rectangles, or a square as a special case rhombus, or a square, rectangle or rhombus as a special case of a parallelogram (Knight, 2006).

3.1.4 Van Hiele Level 2 – Analysis

Learners at this level can recognise figures by their properties. They can name and analyse properties of figures, but they are unable to make relationships between these properties (Alex & Mammen, 2016). This level requires a deeper understanding of geometry vocabulary than levels 0 and 1, respectively, as the levels are sequential and hierarchical (Yi, Flores & Wang, 2020; Hoffer, 1981). At this level, learners' description is seen as the ability to identify and understand the attributes of figures to enable learners create or form classes of figures, but learners who do not fully comprehend definitions, are unable to understand or explain the relationship between varying properties may be due to lack of adequate geometry vocabulary.

3.1.5 Van Hiele Level 3 – Informal deduction

Level 3 consists of logical ordering, abstraction or informal deduction. At this stage, learners begin to establish the interrelationship between properties within a class of figures. To do this effectively, learners should understand mathematics and geometry vocabulary at a level commensurate with level 3 (Usiskin, 1982). Learners at this stage understand the description of terms in geometry, and they can give informal descriptions and arguments. At this level, learners can follow formal proofs but are not able to reproduce the proof when starting from a different or unfamiliar premise. Situations occur where learners at level 3 understand that a square is a special case of rectangles because it has all the properties of a rectangle, but a rectangle is not a square because it lacks the property that all four sides must be equal (Knight, 2006). At this level, the understanding of geometry vocabulary is key to enable learners make these connections and assist them to establish these interrelationships.

3.1.6 Van Hiele Level 4 – Deduction

Level 4 is referred to as a deduction stage, wherein a learner can comprehend and appreciate the role of undefined terms, postulate definitions, theorems, and proofs. At this level, the learner is capable of developing and providing proofs from more than one premise or set of conditions, and learners understand the difference between required and adequate information (Knight, 2006). Knight further explained that learners at this level knew that it was adequate for a figure to have four sides if it was to be referred to as a quadrilateral, but it was required for the sides to be congruent if it was to be a square or a rhombus, and it was required that all angles be right angles for it to be a square. Distinguishing between these parameters requires a good understanding of geometry vocabulary. At this level, Alex and Mammen (2016) maintain that learners can manage implications with induction and they can write proofs by themselves.

3.1.7 Van Hiele Level 5 – Rigour

Learners at this level understand the relationship between various systems of geometry. Geometric thinking at this level is characterised by learners' ability to compare different geometry systems. Learners can compare systems based on different axioms and learn various geometries in the absence of concrete models (Alex & Mammen, 2016). In addition, they understand the role and importance of indirect proof or proof by contradiction and proof by contrapositive (Mayberry, 1983).

3.1.8 The Van Hiele Model and geometry vocabulary

The Van Hiele (1986) model is a veritable tool for planning the geometry strand instruction (National Council of Teachers of Mathematics NCTM, 1989). Elementary teachers often demonstrate deficiencies in geometry content knowledge and are usually unable to recognise gaps in learners' geometric thinking (Browning, Edson, Kimani & Aslan-Tutak, 2014). As a result, they select instructional materials and activities which are inappropriate for learners (Yi, Florse & Wang, 2020) contributing to learners' difficulty in the learning of geometry. Teachers' inability to deliver instruction appropriate to the learner's geometric level of thinking immediately indicates that the progression from one level to another depends on the quality of instruction rather than age and maturity (Jupri, Gozali & Usdiyana, 2020; Clements & Battista, 1992; Van Hiele, 1986). Learners will not achieve when learning with materials above their geometric thinking level. This is in agreement with Origa (2000) who explains that each level of the Van Hiele model has its vocabulary, set of symbols and its network of relations uniting these symbols. He argues that if the vocabulary of instruction does not conform with the symbolic language the learner has already developed, no meaningful discussion will be established. As a result, no significant learning will occur. It is important that at each level, the teaching and learning materials should incorporate geometry vocabulary appropriate for that level for the instruction to be comprehensive and of high quality because Van Hiele maintains that each level has its vocabulary (Van Hiele, 1984).

The primary and junior high school sections of the Ghana mathematics syllabus emphasise the first three levels of the Van Hiele model. The syllabus recommends that learners are introduced to levels 4 and 5 at the senior high schools where learners are expected to continue learning, mainly at these two levels (Pirie, Martin & Kieren, 1994). This implies that for learners to perform well in geometry at high school, a strong foundation must be built during the primary school stage. It is noted that the various stages are interrelated; the lower stages are required and mandatory for a thorough understanding of the higher levels. This calls for the teaching and understanding of geometry vocabulary right from the lower levels.

In addition, the preparation of teachers and mathematics educators to teach geometry should ensure that they are adequately prepared and cover all levels, to empower them to transmit knowledge at any required level to the learners as Yi, Flores and Wang (2020) maintain that many elementary teachers often demonstrate deficiencies in geometry content knowledge (Fujita, 2012). Ghana's mathematics syllabus has no mention of the need for the teaching of geometry vocabulary as a prerequisite for a proper understanding of geometry, which will, in turn, enhance learners' performance.

The Van Hiele model is a significant theory in mathematics education. Consequently, the work and research of scholars in geometry education from the 1950s to date has been energised worldwide with specific interest into the levels of learners' geometric thinking processes and the methods schools employ in the teaching of geometry in the classrooms. The significance of Van Hiele's model is derived from its prescription of the need to understand geometric concepts and vocabulary at levels 0 – 5

(Rahim, 2014). Van Hiele identified language structure, or geometry vocabulary, as a critical factor that affects learners' performance and progress in geometry through the Van Hiele levels from 0 to 5. In stressing the importance of geometry language, Van Hiele notes that many failures in the teaching of geometry result from a language barrier which comes from the teacher using the language of a higher level of geometric thinking than is understood by the learner (Fuys, Geddes & Tischler, 1988). The levels are hierarchical and each level is characterised by its special vocabulary (Chiphambo & Feza, 2020).

Genz (2005) in her study on determining high school geometry learners' geometric understanding using Van Hiele levels examined 20 ninth-grade learners' levels of geometric understanding at the beginning of their high school geometry course. Ten of the learners were taught mathematics using a standards-based curriculum, during grades 6, 7 and 8, and the remaining 10 learners had been taught from a traditional curriculum in grades 6, 7 and 8.

The ten learners who were taught mathematics using a standards-based curriculum showed higher levels of geometric understanding than the learners taught with a more traditional curriculum background. In addition, three distinctions of learners' geometric understanding were identified among learners within a given Van Hiele level, one of which was the learners' use of language. The use of precise versus imprecise language in learners' explanations and reasoning is a major distinguishing factor between different levels of geometric understanding among the learners in this study. This study indicates that using the Van Hiele model emphasises the use and importance of geometry vocabulary as learners' ability to use the geometry vocabulary at each level is crucial.

The Van Hiele model frames this study. Firstly, it guided the development of the pre/post-test questions used to test learners' understanding of basic geometry. Secondly, it informed the development of the instructional materials used during the intervention carried out in this study.

3.2 CONSTRUCTIVIST THEORY OF LEARNING

3.2.1 Background

Constructivism approach to learning can be explained using three major principles. First, learners construct their knowledge with their prior knowledge. Second, learning is an active process. Third, learning is constructed socially (Neutzling, Pratt & Parker, 2019; Rovegno & Dolly, 2006). The theory of constructivism of learning has its origin and foundation in psychology and philosophy with Piaget and Vygotsky's theories as the cornerstone (Schunk, 1999). The main thrust of constructivist learning is predicated on the perception that learners are not passive and that learning occurs when learners have the opportunity to think critically about what they are learning and take decisions. As a result, understanding comes from making meaningful connections between prior knowledge, new knowledge and the learning process (McLeod, 2019). Going by the constructivism theory, it could be said that learners would construct their knowledge and meaning of geometry when they are taught geometry and geometry vocabulary and have the opportunity to interact and discuss geometry using geometry vocabulary.

The Constructivist Theory indicates that the learner is the centre of the learning process, and learner-centred learning can be set up in various ways (Henson, 2003; Anderson, Spigner-Littles & Chalon, 1999). Learners usually assimilate taught lessons better when they learn by experience-based methods, and this is a major key to the construction of new meaning (Merriam, Cafarella & Baumgartner, 2007). It can be argued that the use of geometry vocabularies by learners in class would be a valuable experience that could support the learning of geometry.

The initial work of constructivism is derived from the studies of Dewey, Vygotsky and Piaget (Davis & Sumara, 2002; Henson, 2003; Huang, 2002; Merriam, Caffarella & Baumgartner, 2007). The focus of constructivism is on learning, and not teaching. This gives credence to the opinion that the classroom should be learner-centred rather than teacher-centred (Proulx, 2006). There are two major viewpoints in the Constructivist Theory - the individual constructivist view, and the social constructivist view (Driver, Asoko, Leach, Mortimer & Scott, 1994). The individual constructivist viewpoint portends to indicate that learning is a personal and internal process, whereby the individual develops knowledge based on the individual's previous and current knowledge structure (Driver et al., 1994). In respect of social constructivism, Vygotsky's work is the foundation of social constructivism in educational settings. Vygotsky's emphasis on the role of others, or the social context in learning, has pushed educators to re-examine the extent to which learning is an individual process. As explained earlier, before the recent interest in the social construction of knowledge, the attention was placed almost exclusively on the individual through behaviourist and Piagetian educational applications. Vygotsky's theories have turned this focus upside down by emphasising the role of the greater community and the role of significant others in the learning process (Jones, Brader – Araje, 2002).

In developing the process of learning to benefit learners on an expansive basis, the teacher must consider the peculiarities of the learners. The development of curriculum for adequate learning should consider learner's perspective to conceptualise an adequate curriculum to effectively deliver the educational learning requirements to the learners (Garmston, 1996; Henson, 2003; Anderson, Spigner-Littles & Chalon, 1999). Learners learn mathematics and geometry vocabulary usually by chance, as they encounter them in the concept during lessons. However, teachers should employ different strategies while teaching geometry and geometry vocabulary to meet the needs of diverse learners in the class.

Constructivism in education was a product of the behaviourist movement, and it came as a welcome and refreshing understanding from the perception that portrays the learner as the centre of the teaching-learning process (Jones & Brader-Araye, 2002). This emphasis on the individual (within the greater social context) during instruction has drawn attention to the prior beliefs, knowledge, and skills that individuals bring with them. Prior knowledge has been shown to significantly influence the ways individuals make meaning of instruction. The constructivist focus on the social context and larger community of learners has resulted in a major shift away from individual-based instruction, to instruction that incorporates and embeds teaching within the larger community of peers, younger learners, as well as those who are older. Constructivism's greatest contribution to education may be through the shift in emphasis from knowledge as a product, to knowing as a process. According to Jones and Brader – Araje (2002), this legacy of constructivism will likely prove to be a lasting and meaningful shift in the structure of schooling. This study intended to find the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in selected schools in Ghana. The Constructivist Theory, according to Cooperstein and Kocevar-Weidinger (2004), is a theory based on observation and scientific study about how people learn. It says that people construct their understanding and knowledge of the world through experiencing things and reflecting on those experiences. The immediate relationship of the Constructivist Theory to this study is the researcher's inquiry into the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry. The Constructivist Theory gives an adequate platform to understand the influence of the teaching and the resultant understanding of the learners of mathematics vocabulary associated with geometry on their performance in geometry. The process of teaching involved learners handling geometrical objects, discussing them using appropriate geometry vocabulary, and allowing them to reflect on their experiences.

According to Qarareh (2016, p.181), “The Constructivist Learning Model focuses on the learner as a centre for the learning process, able to build knowledge by himself through the collection of information and data, the formation of hypotheses, access to results and generalisations, discuss solutions, ideas and concepts, and develop them through interaction with others, then apply the findings in new educational conditions and situations.”

3.2.2 Connection between Mathematics Vocabulary Teaching and Learning in Constructivism

This study is an investigation into the influence of the teaching of mathematics vocabulary associated with geometry on the performance of primary six learners in geometry in Ghana. The study observed the influence of the learning and understanding of geometry vocabulary among primary six learners. According to Neutzling, Pratt and Parker (2019, p.775):

> Vygotsky (1997) emphasised the importance of social interaction and cooperative learning in the construction of knowledge while groups engage with each other. He contended that collective social experiences within various social environments affect the social orientation of individuals that ultimately influences their cognitive functions.

This study relied on the Constructivist Theory in mathematics, which indicated that learners were not passive receptors of information but initiators of new concepts and knowledge that is predicated on previous experiences, assimilation, current knowledge and social interactions. This is diametrically opposed to the concept of rote learning. The teaching of mathematics vocabulary associated with geometry should not be by rote. Learners should be made to engage with the vocabulary, discuss them and explore individually and in small groups.

Constructivism has leaned towards a more enterprising mode of tutoring, where the learner’s ideas are ventilated in class, acknowledged and enhanced through continuous interaction, and the use of teaching and learning methods which are actively deployed during the teacher-learner interaction (Major & Mangope, 2012). This is applicable in the learning of mathematics and geometry vocabulary since mathematics and geometry learning in higher classes is greatly dependent on knowledge acquired in the lower classes.

Van der Sandt (2007) states that teachers have a perception about the subject of mathematics with its learning and teaching methods. The teachers may have a mindset that indicates that mathematics as a discipline comprises strict rules and regulations to adhere to for the learners to acquire appropriate knowledge. They may propound that the subject of mathematics has sequential and consistent patterns and logic that must be enumerated for learners to discover the essence of mathematics. The teachers might further have an understanding, to the effect, that mathematics is a problem-solving process. In an attempt for learners to solve problems, they engage in discussions and interactions in the learning environment (Ernest, 1989). The discussions and interactions when attempting to solve problems in geometry involve the use of geometry vocabulary and learners construct their learning through all these experiences.

Van der Sandt (2007) explains that teachers are prone to make decisions according to their beliefs and understanding. He further stipulated that the reforms experienced in mathematics were guided by those who comprehended that mathematics was essentially a changing body of knowledge formulated by respective people and scholars. However, constructivism maintains that learners be involved in the decisions regarding their learning (Ahmed, Ching, Yahaya & Abdullah, 2015). Brackenbury (2012) purports that learners create new knowledge and skills as they interact with each other, comparing and contrasting their new experiences and their previous knowledge. Further, learners should be inspired and assisted to create their understanding of mathematics and geometry through their experiences with the vocabulary.

3.2.3 Relationship between Constructivism and Geometry

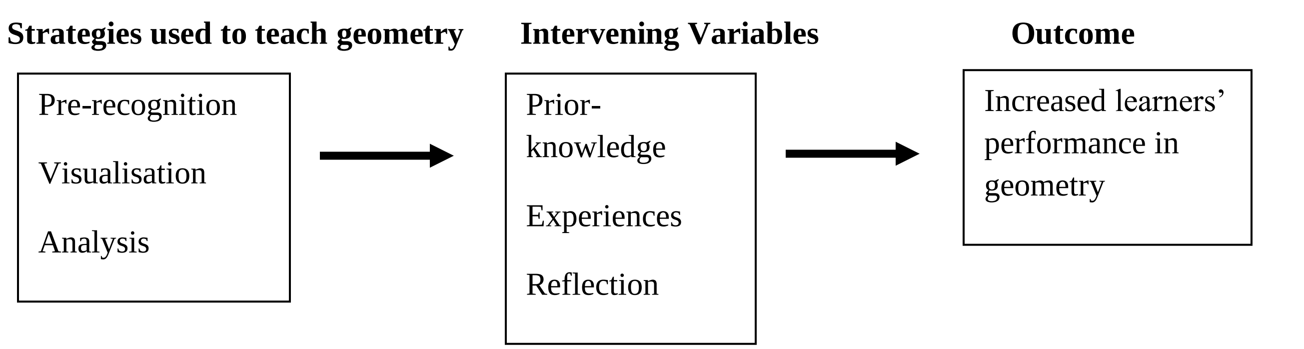
Teachers should understand that learners already have prior knowledge and build new knowledge on the foundation of previous knowledge (McLeod, 2019). Proulx (2006) insists that learners' prior knowledge should be accorded necessary recognition. It may be used in producing further knowledge in the subject area. He also maintains that learners have a role to play in the learning space since they are required to communicate the new knowledge which has been constructed in the individual.

The constructivist education environment requires that the teachers must be receptive of learning from their learners whenever the learners are involved in the creative construction of new ideas and concepts. Tam (2000) explains that teachers and learners share knowledge in a constructivist learning environment. This portends that as the learners express their newly constructed understanding, they ensure that other learners in the learning space also benefit as they all continue in the process of revising, analysing and improving their concepts as they understand them (Proulx, 2006). Mathematics vocabulary teaching and learning could easily be used to achieve this.

Constructivism according to Schunk (1999) has influenced educational thinking regarding curriculum and teaching. It encourages an integrated curriculum which enables learners to study a topic from multiple perspectives. For example, in studying 3-D objects, learners could make a collection of 3-D objects from their environment, draw pictures of the objects, discover and write down the properties of these objects through observing and manipulating them individually and in small groups, discuss the uses of these objects and where they can be found. The teacher structures the lesson in such a way that learners are actively involved with the content through manipulation of the objects and social interactions. The role of the teacher in a constructivist learning environment is to elicit and support learners' thinking and meaning-making abilities (Ahmed et al., 2015). A lesson on 3-D objects delivered in this manner would assist learners to construct their learning through their experiences with the objects and their discussions using geometry vocabulary. This would, in turn, make the learning more permanent.

Draper (2002) maintains that using constructivism is a veritable tool for teachers and educators to understand how learners conceptualise and learn mathematics. Using constructivist pedagogy, educators can make learners more comfortable in the classrooms, ensure that meaningful and useful discussions are undertaken in mathematics and geometry using appropriate vocabulary and, in the process, encourage them to formulate new concepts and knowledge in mathematics and geometry. This will ensure a conducive learning environment where learners are comfortable and respected (Henson, 2003; Anderson & Spigner-Littles, 1999).

Below is the conceptual diagram of this study.



3.3 CHAPTER SUMMARY

The Van Hiele Model and the Constructivist Theory of learning were discussed in this chapter as the two theories that underpinned this study. The Van Hiele model gives us a clear understanding of the required levels of geometric thinking. It can be argued that when learners have materials appropriate to their geometric thinking level, they build on the previous knowledge acquired through their learning experiences. This allows learners to construct their knowledge and meaning of geometry that will, as an outcome, enhance learners' performance in geometry. Going by the constructivist learning approach, there is a need for adequate development of geometry vocabulary to allow learners to construct their knowledge of geometry through their experiences with the vocabulary of geometry, which is required in several spheres of education (Yi, Flores & Wang, 2020) and application to society.

The study of geometry assists learners in the development of problem-solving and critical thinking skills necessary for survival and innovations in the 21st century (Chiphambo & Feza, 2020; Hassan, Abdullah & Ismail, 2020). To an extent, the development of geometric thinking could be achieved through the teaching and learning of geometry vocabulary as it was clear from the literature that the understanding of mathematics vocabulary assisted learners to comprehend and understand mathematical concepts better as explained by Bhuvaneswari and Umamaheswari (2020). In conclusion, the constructivist learning approach provides a suitable environment for the learning of geometry and geometry vocabularies, as it encourages learners to construct their knowledge of geometry and its vocabulary based on their experiences. In addition, the constructivist environment allows learners to learn geometry and geometry vocabularies based on previous knowledge thereby supporting the Van Hiele model to assist learners graduate from one level of knowledge to another.

CHAPTER 4: RESEARCH METHODOLOGY

4.0 INTRODUCTION

This section describes the philosophical foundations and paradigms of this study. It also contains discussions and analysis of the specific research design, population, sampling design, and procedures. Issues related to the sample size, instrument design, instrument validity, reliability and data collection procedures aimed at investigating the influence of mathematics vocabulary teaching on primary six learners' performance in geometry are also discussed.

The process of research is the systematic investigation and study of materials and sources necessary to establish facts and make new conclusions (Rajasekar, Philominathan & Chinnathanmbi, 2011). The development of knowledge is based on the effectiveness of the research methodology process. Marshall and Rossman postulate that research is conducted to address an issue, resolve a problem or discourse and an argument to understand the universe. This process establishes facts and new inclusions (Marshall & Rossman, 2011). This aligns with this research since the issue being addressed is to investigate the influence of mathematics vocabulary teaching on learners' performance in geometry.

In the process of this study, the researcher intended to explore and improve the method of teaching geometry in primary schools in the Greater Accra Region in Ghana, to include the teaching of geometry vocabulary and mathematics vocabulary during mathematics lessons. This contrasts with the traditional theory-oriented method of teaching or explaining mathematics concepts without in-depth teaching of mathematics vocabulary. Drawing an inference from the postulates of Horkheimer (1972), the researcher sought to dig beneath the surface of the system of teaching geometry, to ascertain the strategies used by the teachers and their perception on the teaching of geometry vocabulary. This assisted the researcher to discover whether geometry vocabularies were taught in primary six, and investigated the extent to which that influenced learner's performance in geometry.

The process of research involves three main methods, namely exploratory research, descriptive research and explanatory research (Saunders, Lewis & Thornhill, 2009). The researcher undertook explanatory-exploratory research. This research is explanatory because the researcher intended to confirm or reject the conjecture that mathematics vocabulary teaching has a positive influence on the performance of primary six learners in geometry. The study is exploratory because the researcher intended to observe and find out if geometry vocabularies were taught and the strategies used in the teaching of geometry in the selected schools. Observation is a key component of exploration. These observations are based on scientific methods which mean the research must be applicable and precise; which leads to the conclusion that it should be more reliable than causal observations (Bhattacherjee, 2012).

4.1 THE PHILOSOPHICAL PARADIGMS

A paradigm is a framework containing all the commonly accepted views about a subject, conventions about what direction research should take, and how it should be performed. Paradigms contain all the distinct, established patterns, theories, common methods and standards that allow us to recognise an experimental result as belonging to a field or not. It dictates what is observed and measured; the questions we ask about those observations; how the questions are formulated; procedures for carrying out the research; determining the appropriate equipment to be used and interpretation of results. The philosophical paradigms employed in this study are discussed below.

4.1.1 Ontology of the researcher

Ontology is the philosophical study of the nature of reality (Hudson & Ozanne, 1988) or the nature of 'being'. Ontology is the philosophy of how one understands reality. It refers to the specification of a concept (Gruber, 1993); the nature of social reality to an individual. The central orientation in ontology refers to two most required questions, which are (a) social constructs can and should be seen as real, objective and external to the social actor, and (b) social constructs may be considered as internally built-up concepts predicated on the subjective views of the researcher (Bryman, 2001). The real, objective and external paradigm is segmented as the positivist, while the internal and subjective paradigm is referred to as the interpretivist in the epistemological context (Burrell & Morgan, 1979).

The researcher is ontologically an interpretivist because she finds social constructs subjective in consideration and understands that the performance of learners in geometry may be based on their knowledge of the concepts. As a positivist, the researcher also sees social constructs as objective in certain circumstances and bringing about the view that learners' performance in geometry may be related to the teaching of mathematics and geometry vocabulary. This combined approach has informed the use of both subjective and objective methods of research in this study to discover the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry.

4.1.2 Positivism

The positivist paradigm considers objectivism its greatest attribute, it considers its objective facts as measurable and it uses statistics to test causal relationships (Scotland, 2012). Positivists put great value on the principle of replication and tend to use large samples as well as rating the principle of replication highly. Positivism is understood to be a scientific method of study or science-based research. The positivist and realist philosophy are deterministic in perspective and causes are estimated to determine effects or outcomes (Creswell, Clark, Gutmann & Hanson, 2003). The researcher is positivist in her approach because she wants to find out whether learners will perform better in geometry if they are taught geometry vocabulary.

4.1.3 Interpretivist /constructivist perspective

Interpretivists posit that there is more than one reality, and many means of obtaining knowledge about such realities. The interpretivist develops knowledge through socially constructed and subjective perspectives. Interpretivists are receptive and accessible during their research, and they allow the respondents to contribute immensely to the narratives (Hudson & Ozanne, 1988). The researcher is accessible to both the learners and the teachers participating in this study, and the participants can contribute objectively and subjectively to the outcome of the research.

Going with the postulations of Von Wright (1971), the researcher intended to develop an objective understanding and knowledge of the influence of mathematics vocabulary teaching on the performance of primary six learners' in geometry in the Greater Accra Region of Ghana using an empathic and objective understanding of the situation through a mixed-method approach.

4.1.4 Critical realism perspective

The researcher, in a bid to explore and discover the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in the Greater Accra Region of Ghana, adopted the critical realist approach that emphasises the multi-layered nature of social reality (Myers & Newman, 2007). Critical realism as a research platform combines attributes of both positivism and interpretivism (Healy & Perry, 2000).

Using the epistemological lens, Dobson (2002) notes that the critical realist is of the view that our understanding of reality is a consequence of our socialisation process. Therefore, reality cannot be fully appreciated without the input of all social actors who participate in the knowledge development process. It questions the understanding that the reality itself is a product of this knowledge derivation process. This research is investigating the influence of mathematics vocabulary teaching on primary six learners' performance in geometry. Does the teaching of geometry vocabulary, in reality, influence the performance of primary six learners' in geometry? With realism, the seeming dichotomy between quantitative and qualitative studies is therefore replaced by the mixed-method approach adopted in this research. This is considered appropriate given the amount of existing knowledge on the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in the Greater Accra Region of Ghana.

The objective of a research study determines the choice of the particular paradigm adopted for the research (Cavaye, 1996). The choice of Realism as the philosophical paradigm guiding this work was selected because there is a need to adequately match the methodology employed and the philosophical persuasion (Hitchcock & Hughes, 1995). They also postulate that epistemological inclinations are a determinant factor in determining the type of data collection and analysis instruments. This suits the research; hence, the combination of both quantitative and qualitative approaches.

4.2 RESEARCH DESIGN

The researcher's theoretical lens plays an important role in the choice of methods (Creswell, 2013). The underlying epistemological assumptions of the research in exploring and discovering the strategies used in the teaching of geometry and in explaining or confirming the influence of the teaching of mathematics vocabulary on the performance of primary six learners in geometry in the Greater Accra Region of Ghana largely define the choice of the research method.

4.2.1 Rationale for using a Mixed-method Approach

To achieve the aim of this study, the researcher used a mixed research design employing both qualitative and quantitative approaches and used numerical data analysis and non-numerical narratives. In the process of using the quantitative procedure, the researcher relied on statistical procedures, while in using the qualitative procedure, the researcher relied on categorising and organising data into patterns to produce a descriptive, narrative synthesis. The essence is to build on the synergy and strength that exists between quantitative and qualitative research methods, to understand the research phenomenon more fully than is possible using either the quantitative or qualitative methods alone (Gray, Mills & Airasian, 2009).

This research design has the capabilities of providing both broad results from the surveys and the test scores, and deep results from the interview data. This design was appropriate since the researcher investigated the strategies that primary six teachers used to teach geometry, the teachers' perception on geometry vocabulary teaching, and how geometry vocabularies were taught and the influence of geometry vocabulary teaching on the performance of the learners through the use of questionnaires, a geometry achievement test, and interviews. Using this approach, open-ended and emerging data was collected with the primary intent to develop themes from data (Creswell, 2009). Essential data was collected through questionnaires, pre-test of learners' understanding of basic geometry, post-test of learners' understanding of basic geometry and interviews. The qualitative methods used in this thesis are one-on-one, face-to-face interviews.

In undergoing the research, the Qual-Quan Model, which is known as the concurrent triangulation mixed-method design, was adopted. In the process, qualitative and quantitative data were collected concurrently throughout the study, and they were equally weighted where the strengths of the qualitative data offset the weaknesses of the quantitative data, and vice versa (Creswell & Creswell, 2017).

4.2.2 Quantitative research method

Quantitative research is considered as a deductive approach towards research, deductive in that it is provable (Almalki, 2016). Corbin and Strauss (2008) assert that quantitative research is a formal, objective, systematic process to describe and test relationships, and examine cause and effect interactions among variables. The researcher adopted quantitative research to ask specific and narrow questions, collect quantifiable data from participants and analyse these numbers using simple percentages. This study poses questions that can be measured and quantified (Creswell, 2010). This research has produced numeric data, based on measurements, which gives broader trends, broader generalizations, and specific variables with a large population (Rajasekar et al., 2011).

Quantitative research is closely linked with the positivist/post-positivist paradigm. During this study, data was collected and converted into numerical format. This enables simple percentages to be calculated, and relevant conclusions drawn on this basis (Saunders, Thornhill & Lewis, 2012). However, critics of this approach (Corbin & Strauss, 2008) have expressed numerous misgivings about its use. Bryman (1993) for example, criticizes quantitative research methods for their apparent orderliness and linearity, and their lack of concern over the influence of resource constraints. Kaplan and Duchon (1988) argue that the stripping of context through using a closed survey instrument, although it could enable objectivity and testability, costs the research, however, a deeper understanding of what is actually occurring, hence the use of both methods in this study.

In this quantitative approach, the researcher used two hundred and fifty-seven respondents comprising two hundred and fifty learners, and seven teachers. In addition, listed questions were raised and response choices were predetermined. Bazeley (2011) postulates that the quantitative research approach is best to investigate the perceptions and problems of the study, and to discover the hidden values, feelings, attitudes and motivations. The researcher also administered a test of basic geometry to the learners to test the learners' understanding of basic geometry vocabulary. This is referred to as the pre-test of basic geometry. After the pre-test, the researcher carried out an intervention which entailed teaching the learner's geometry vocabulary. At the end of five hours of teaching and learning mathematics vocabulary associated with geometry, the researcher reshuffled the test items on the pre-test and returned on a later date to administer it as a post-test of basic geometry. The test items were reshuffled to reduce practice effect. The results of the pre-test and post-test were recorded and analysed to determine the influence of geometry vocabulary teaching on learners' performance.

4.2.3 Qualitative research method

The researcher applied the qualitative research approach, which is also linked with the social constructivist paradigm, which depicts the socially determined nature of reality. In the process, the researcher recorded interviews and analysed them to explore and discover the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in the Greater Accra Region of Ghana.

Cohen and Crabtree (2006) maintain that in qualitative analysis, the focus is not on the qualification of facts, but on identifying meaning and values attributed by the respondents in their real-life situation. The researcher carried out recorded interviews with five learners from each of the participating schools and the seven participating teachers, and ensured that data generated from the qualitative study was analysed with the aid of identifying ideas, broad themes, and patterns that emerged from the data to arrive at the findings (Braun & Clarke, 2006).

Interpretivist/constructivist methods of research were undertaken to study the world of human experience (Cohen, Manion & Morrison, 1994). This also implies the presence of multiple realities

and gives credence to the perception that reality is socially constructed (Mertens, 2005). The researcher, using the interpretivist/constructivist philosophy, draws her standpoints from the views of participants in respect of the phenomenon under study (Creswell et al., 2003) which, in this case, is the influence of mathematics vocabulary teaching on primary six learners' performance in geometry.
Objectivity is very important in this research, but total objectivity cannot be obtained since the researcher and the participants are human. Since the intention of the researcher is to discover the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in the Greater Accra Region of Ghana, the researcher has taken care to avoid making prejudiced remarks. Qualitative approach is actually more inductive than deductive.

4.2.4 Inductive and deductive research

Induction and deduction are methods of logic through which attempts are made to solve problems. In induction, the researcher studies the general characteristics in a set or group of observations, and the latter identifies a particular instance through its resemblance to a set, or group of known instances, or observations (Mertens, 2009). Inductivism ascribes to the argument that we arrive at objective, unbiased conclusions only through recording, measuring and describing what we encounter without any root hypothesis (Mertens, 2009). The deduction, on the other hand, is inferred via reasoning from generals to particulars, or the process of deducing from something known or assumed (Mertens, 2009).

The researcher has adopted induction and deduction to analyse data collected for this thesis. The researcher has a simultaneous mindset with one directed toward the specific aim of the study, and an open-minded one is necessary so that while searching for information on the influence of mathematics vocabulary teaching on learners' performance in geometry and the strategies used in the teaching of geometry which are the objectives of the study, the researcher is also alert to understand the unexpected (Mertens, 2009).

4.2.5 Description of Research Sites

This research was carried out in three schools, namely School 1, School 2 and School 3, all in Accra in the Greater Accra Region of Ghana.
School 1 is a privately-owned school with a population of 691 learners from kindergarten to junior secondary school. The school was founded in June 1965 and has a teaching staff of 25 teachers, of which two are primary six mathematics teachers.

School 2 is a privately-owned school founded in 1975. It currently has 960 learners from kindergarten to junior secondary school. There are 40 teaching staff of which three are primary six mathematics teachers.

School 3 was established in 1957 as a private mission school of a church. The school has 1,009 learners with 48 teachers, of which two are primary six mathematics teachers.

Table 4.1: Profile of selected schools

Name of school	**Total number of learners**	**Number of teachers**	**Number of Mathematics teachers**
School 1	691	25	2
School 2	960	40	3
School 3	1009	48	2

[see Appendix C]

The three schools offer a nine-year basic education programme, largely following the Ghana Education Service syllabus, and they prepare learners for the Basic Education Certificate Examination (BECE) conducted by the West African Examination Council at the end of the nine years. The schools are located within a thirty-kilometre drive away from each other, in safe and serene areas of Accra. There is minimum distraction, which supports learners' focus and concentration during the school day. The three schools have similar socio-economic status and are all easily accessible.

4.2.6 Learner Participants

The learner participants comprised all the primary six learners of the three selected schools in the Greater Accra region. A total of 250 learners participated in this study, and the statistics are as follows:

Table 4.2: Schools and number of participating learners

Name of school	**Number of boys**	**Number of girls**	**Total number of learners**
School 1	23	29	52
School 2	51	37	88
School 3	56	54	110
Total	129	121	250

[see Appendix C]

4.2.7 Teacher Participants

A total of seven primary six mathematics teachers participated in this study. The statistics are as follows:

Table 4.3: Information on teacher participants

Status	**Sex**	**Age (Years)**	**Qualification**	**Years of experience**
Teacher 1	Male	30	B.Sc Mathematics	3
Teacher 2	Male	55	A Level	15
Teacher 3	Male	50	B.Sc Administration/ HND Statistics	23
Teacher 4	Male	50	Teacher's Certificate/ B.Sc Business Administration	22
Teacher 5	Female	47	B. Ed Basic Education	28
Teacher 6	Male	53	B. Ed English	17
Teacher 7	Male	46	Diploma in Education	25

[see Appendix C]

4.3 SAMPLING TECHNIQUES

A sample is a subset of the population of the study, and sampling is a process of choosing from a much larger population, a group about which we wish to make general statements so that the selected part will represent the whole group (Bailey, 2008). For this research, the study site for this study is Accra, and the sample population is from the three selected schools in Accra. The researcher used schools in Accra due to availability of financial resources, proximity, time factor and the researcher's interest in Accra having taught in a primary school in Accra for over thirteen years. There are two main types of sampling technique: probability and non-probability sampling. This study adopts the non-probability sampling technique, specifically convenience and purposive sampling.

4.3.1 Purposive sampling

Purposive sampling involves identifying and selecting participants that are knowledgeable about a phenomenon of interest, considering availability and willingness to participate. Also, the ability to communicate responses adequately (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2015). A purposive sampling technique was used in selecting the schools in Accra that participated in the study. Purposive sampling was adopted in this study because the researcher needed to select schools to which the researcher has access to conduct the research. Also, the researcher needed to select schools which met the criteria for the research. This included schools that were easily accessible, used the same curriculum and were privately owned. This sampling method is justifiable because primary schools that met the criteria for this study were selected.

4.3.2 Convenience sampling

Convenience sampling is a type of sampling where the first available primary data source is used for the research without additional requirements (Saunders, Thornhill & Lewis, 2012). In other words, this sampling method involves getting participants wherever you can find them and, typically, wherever is convenient. In convenience sampling, no inclusion criteria are identified prior to the selection of subjects. All subjects are invited to participate. The convenience sampling method was used in choosing the learners and teachers respectively for this study. All the class six learners, and all the primary six mathematics teachers in the selected schools were chosen to participate in the study.

4.3.3 Population

Leedy and Ormrod (2005) defined the population as the entire set of objectives and events, or group of people, which is the subject of research and about which the researcher wants to determine some characteristics. For this study, the population of the study comprises all primary six learners and primary six mathematics teachers in Accra. Since over 50 accredited primary schools exist in the Ridge area of Accra alone, the researcher found it imperative and expedient to base the study in Accra.

4.3.4 Sample size

Sample size refers to the number of individuals or participants in an experiment, or a survey, taken from a larger group of the population. The entire 282 primary six learners in the three schools and the eight mathematics teachers consented and started at the onset of the study. However, in the course of the study, 32 learners and one teacher dropped out of the study, bringing the total sample size to 257 participants, of which 250 are learners, and seven are teachers.

4.4 DATA COLLECTION INSTRUMENTS

4.4.1 Questionnaire development

Questionnaires are written forms of papers on which questions are asked and information about a research study is gathered (Leedy & Ormrod, 2005). The researcher chose the questionnaire as a data collection tool because in close-ended questions, respondents are offered a set of answers from which they were asked to choose the answers that most closely represented their views, and the respondents did not waste time thinking of what to write as answers were provided. This study adopted the 5-point Likert Scale questionnaires for both the teachers and learners (see Appendix A and Appendix B). The questionnaire helped the researcher to limit the responses from respondents regarding the objectives and research questions.

The item questions were asked in a logical order, as much as possible, to avoid causing any confusion in the minds of the respondents. The researcher made sure that the sequence of the questions followed the sequence of the objectives of the study, or the research questions so that the respondents would be answering the research questions clearly. For instance, a primary objective of the study was to find out how geometry vocabularies were taught and the influence of mathematics vocabulary teaching on the performance of the learners in geometry.

The teachers' and learners' questionnaires comprised two sections - A and B, respectively. Questions in section A of both questionnaires sought to elicit some demographic information about the participants. Questions in section B of the teachers' questionnaire sought to find the strategies the teachers employed in the teaching of geometry, how the teachers taught geometry vocabularies, and the teachers' perception on the teaching of geometry vocabulary and its influence on learners' performance in geometry. The section B of the learners' questionnaire comprised questions designed to find out whether the participating learners knew what was referred to as mathematics vocabularies and geometry vocabularies, whether they were taught mathematics vocabulary and geometry vocabulary, and the influence of mathematics vocabulary and geometry vocabulary teaching on their performance in mathematics and geometry.

4.4.2 Development of pre-test and post-test

The researcher designed a test of basic geometry to test learners' understanding of geometry based on their understanding of geometry vocabulary. The content of the geometry achievement test was based on the expectations of the Ghana mathematics syllabus for primary 4-6 and was guided by the Van Hiele model, which is one of the theories that frame this study. The geometry vocabulary words were taken from the list of vocabularies contained in the Ghana mathematics syllabus for primary 4-6 learners. The test paper did not require learners to write their names; the only extra information required was the name of school, date and the learner number which was assigned to each learner at the onset. These numbers were assigned to each learner to enable the researcher to compare the pre-test and post-test results for each participant. The pre-test comprised 20 questions of different types. Ten questions were multiple choice, and learners were required to circle the correct answer. Another 10 questions required learners to fill in the gap, while two questions required learners to work out the answer to the question before they could fill in the gap (see Appendix D and E).

4.4.3 Development of the interview questions for teachers and learners

Interviews are conversations to obtain information from respondents and allow for close interaction between the researcher and the participants (Sveningsson & Alvesson, 2008). One of the methods widely accepted in the scientific world and used for gathering the relevant data for this study was an in-depth interview. The interview questions for both teachers and learners were designed to answer the research questions (see Appendix F and Appendix G).

4.4.4 The Pilot Study

A pilot study was conducted to improve the validity and reliability of the instruments. The teachers' and learners' questionnaires were administered to 20 primary six learners, and two class six mathematics teachers at an educational centre at Labone in Accra, Ghana, which resembled the selected schools but was not chosen as an actual research site. The results were shared with experts, and the suggestions received from the experts were incorporated to fine-tune the contents of the instruments; the questionnaires, the geometry achievement test, pre-test and post-test, to make them valid for the study. The questionnaire was edited for clarity to suit the actual sample for the study, and the geometry achievement test was refined to meet the cognitive demand of primary six learners using the Ghanaian Mathematics Syllabus (see Appendix F & G).

4.4.5 Reliability and validity of instruments

This section ensures that the research tools, questionnaire and interview adopted in this study are reliable and valid. Reliability is related to accuracy. Reliability and validity are, therefore, the bedrock of quality measures (Pearson, 2010). Based on positivism paradigm, Mugenda (2008) asserts strict criteria for judging the quality of the research findings in terms of objectivity, and that one must show evidence that the findings are consistent with occurrences in the real world. Thus, validity and reliability were used to express the quality of the data collected.

Validity is traditionally defined as an argument in support of a construct made using data. However, its meaning changes as an investigator adopts different scientific philosophies, descriptions of entities to be measured, and norms for acceptable data (Salkind, 2010). One way of demonstrating validity is to record detailed information about the actual survey instrument used (Gerhardt, 2004). To ensure content validity of the instruments, the two sets of questionnaires and the geometry achievement test were designed and submitted to mathematics education experts for scrutiny since according to Pearson (2010) validity can be determined through expert judgment.

4.5 DATA COLLECTION PROCEDURES

4.5.1 Questionnaire administration

The fieldwork was carried out between December 2016 and February 2017. The researcher was assigned a day in each of the participating schools for the administration of the questionnaires and pre-test of basic geometry. The researcher and the research assistant administered the questionnaires on the assigned day in each school. The researcher trained the research assistant, who is a master's student in one of the renowned tertiary institutions in Accra, before the commencement of the study. Being a master's degree student, research procedure was familiar terrain for her. Each participating teacher, and participating learner, was given a questionnaire to complete while the researcher and the research assistant waited in the school as the participants filled out the questionnaires during the allotted time. At the end of the time allotted, the researcher and the research assistant returned to the class to collect the completed questionnaires. This mode of distribution of questionnaires was chosen over other modes, because when a researcher himself/herself, or somebody else is chosen to deliver the questionnaires and then pick them up, or both, the completion rate is higher (Babbie & Maxfield, 2011). Since the schools allocated time for that purpose, it made the procedure for questionnaire administration and collection effective and efficient.

4.5.2 Administration of pre-test

The researcher and the research assistant administered the test paper and read the instructions on the test paper with the learners to ensure that learners understood what they were required to do. The learners were given an hour to complete the test to ensure that each learner had enough time. This was because the researcher was testing for the understanding of geometry vocabulary and its simple applications, and not for learners' speed. The researcher and her assistant invigilated the test in the natural learning environment of the learners without any distractions. Learners were given an hour to complete the test within which all the learners submitted their work after they certified that they had completed the test and had crosschecked their work.

4.5.3 The intervention

After the pre-test, the researcher carried out an intervention the following week by teaching the learners geometry vocabulary with emphasis on the understanding of the meaning of the words. The intervention involved the researcher teaching the learners basic geometry vocabulary using various methods, including word search, finding the meaning of the given geometry vocabulary using a mathematics dictionary, using a geometry vocabulary activity sheet designed by the researcher, and playing bingo. The teaching materials used during the intervention were guided by the Van Hiele model which is one of the theories that underpin this study. The researcher originally intended to train the primary six mathematics teachers in the participating schools to carry out the intervention to eliminate the researcher's bias. However, the teachers declined the training due to time constraints. As a result, the researcher had to carry out the intervention herself, supported by the research assistant. The intervention was carried out over a period of five days, and the researcher taught the learners twenty geometry vocabulary words using the strategies mentioned above for an hour each day. The researcher developed a geometry vocabulary activity sheet which she also used during the intervention (see Appendix J). The learners' responses to the class exercise during the fifth day showed that the learners had gained a good understanding of the meaning of the geometry vocabularies.

4.5.4 Administration of post-test

A week after the intervention, the researcher and research assistant returned to the schools to administer the post-test. The items on the pre-test were reshuffled to limit practice effect, and the test paper was administered as a post-test of learners' understanding of geometry. The purpose of the post-test was to determine whether the intervention had any impact on learners' performance. The researcher and research assistant administered and invigilated the post-test under the same conditions as the pre-test. All the learners submitted their work within an hour when they were certain that they had completed the test and had crosschecked their work.

4.5.5 The interviews

In-depth interviewing is a qualitative research technique that involves conducting intensive one-on-one conversations with a small number of respondents to explore the perspectives on a particular idea, programme or situation (Boyce & Neale, 2006). The researcher and the research assistant interviewed the seven primary six mathematics teachers, and 15 learner participants (five from each school) one-on-one, for about 45 minutes each. Each interview question was read and explained, and each teacher/learner's response was recorded and played back to them at the end to confirm that the recorded information represented their stand on the questions. The interviews were carried out individually in a room out of the view of their colleagues and open-ended questions were used (see Appendix F and G). An interview is a verbal interchange in which an interviewer tries to elicit information, beliefs or opinions from the interviewee (Burns, 2000). In this study, the interview was conducted to discover the strategies used in the teaching of geometry, teachers' and learners' perception on the teaching of mathematics and geometry vocabulary, how geometry vocabularies are taught and the influence of mathematics vocabulary teaching on the performance of primary six learners in geometry in the selected schools in the Greater Accra Region of Ghana.

4.6 DATA ANALYSIS

Once data is collected, the next stage is to analyse the data and the final step is to report the findings of the study. Flick and Gibbs (2007) explains that the idea of analysis implies a transformation of some sort, where a researcher collects data and attempts to process it through analytic procedures into an understandable, insightful, trustworthy and even original analysis (Onwuegbuzie, Leech & Collins, 2011). It is the stage of research central to both quantitative and qualitative research because the researcher attempts to extract meaning from the collected data and then begins to address the underlying research questions (Flick & Gibbs, 2007; Onwuegbuzie et al., 2011). In this section, the researcher attempts to extract meaning from the collected data and then begins to address the underlying research questions.

4.6.1 Quantitative data analysis of the questionnaires

The questions on the questionnaire were grouped based on their relevance to the objectives of the research. The 5-point Likert Scale, ranging from strongly agree to strongly disagree, was used for easy comparison of participants' responses. It is also a universally accepted method of collecting data because it can be easily understood and replicated (see Appendix C). Participants' responses were converted into percentages, and these percentages were analysed and discussed using tables and charts.

4.6.2 Quantitative data analysis of the pre-test and post-test

The pre-test and post-test papers were marked out of 25 points and converted into a percentage. Each learner's pre-test and post-test scores were recorded and compared. Although learners did not write their names on the test papers, each learner had a number assigned by the researcher for this purpose. The percentage difference in the pre-test and post-test scores of each learner was calculated and recorded. The researcher compared all the percentages and reported on the percentage of learners who had improved on their post-test scores, or who had maintained the same scores despite the intervention, or had scored less in the post-test.

4.6.3 Qualitative data analysis of the interviews

The responses from the interviews were transcribed then analysed thematically using central themes. These are patterns that run across the data that are important to the study and are closely associated with a specific research question (Corbin & Strauss, 1990). The two central themes are the importance of geometry vocabulary teaching and frequency of geometry vocabulary teaching. The data collected from the qualitative survey were analysed manually.

The steps involved included the following:

i. **Transcription** – the first stage of the analysis in which the information gathered during the interviews were played repeatedly and transcribed verbatim.

ii. **Familiarisation** – spending time reading through the verbatim transcriptions of the interviews with the aim of searching for key ideas.

iii. **Separating the data set from the data corpus** – identifying the actual data that is needed for the analysis and isolating them from the entire primary data collected from the field. For example, the data corpus included interviews, questionnaire, pre-test, and post-test. The data corpus is then separated into data sets. For example, Data set 1 – interviews, data set 2 – questionnaires, data set 3 – pre-test scores and data set 4 – post-test scores.

iv. **Coding** – coding was done taking into consideration the specific research questions. After familiarising with the data, the emerging ideas about what was important in answering the research questions were coded manually, using both highlights and abbreviations. For example, *"My teacher uses the shapes of geometry to teach me and I learned a lot. So, it was shapes."* (*L1Q1*). This response is coded as *L1Q1* to mean response of learner 1 to question 1.

The code *(T1Q11)* means the response of teacher 1 to question 11. The code *(L4T3Q11)* for a learner and a teacher's response means the response of learner 4 and teacher 3 to question 11

v. **Thematising codes** – the codes were organised into themes after all data had been coded. The themes captured an overview of identical ideas from the data and showed some pattern within the responses in the data. For instance, after coding, some of the themes which emerged were "the importance of geometry vocabulary teaching" and "frequency of geometry vocabulary teaching" (see Appendix H & I).

4.6.4 Credibility

The credibility criterion involves establishing that the results of qualitative research are credible, or believable, from the perspective of the participants in the research (Trochim, 2019). Since, from this perspective, the purpose of qualitative research is to explain or understand the phenomena of interest from the participant's eyes. The participants are the only ones who can legitimately judge the credibility of the results. It is seen as the most important criterion in establishing trustworthiness. This is because credibility essentially asks the researcher to clearly link the research study's findings with reality to demonstrate the truth of the findings. In this study, the researcher adopts triangulation to establish credibility.

4.6.5 Triangulation

The logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations (Patton, 1999). Because each method reveals different aspects of empirical reality, multiple methods of data collection and analysis provide more grist for the research mill (Patton, 1999). This is used to ensure that the research findings are comprehensive and well-developed. The researcher employed methods of triangulation that involved using of different data collection methods to check the consistency of the findings for this study. The researcher in this study used questionnaires, interviews, results of the pre-test and post-test of learners' understanding of geometry to establish a triangulation.

4.6.6 Transferability

Transferability refers to the degree to which the results of qualitative research can be generalised or transferred to other contexts or settings (Trochim, 2006). From a qualitative perspective, transferability is primarily the responsibility of the one doing the generalising. The qualitative researcher can enhance transferability by doing a thorough job of describing the research context, and the assumptions that were central to the research. The person who wishes to "transfer" the results to a different context is then responsible for making the judgment of how sensible the transfer is. Merriam and Simpson (1995) write that external validity is concerned with the extent to which the findings of one study can be applied to other situations (Shenton, 2004).

In positivist work, the concern often lies in demonstrating that the results of the work at hand can be applied to a wider population. The researcher in this study has explained in detail the number of schools taking part in the study, where they are based as well as the category of participants, which is restricted to only primary six learners and their mathematics teachers. Also, the number of participants involved in the fieldwork, the data collection methods that were employed, and the period over which the data was collected were detailed. In so doing, the researcher has ensured that transferability was established.

4.6.7 Dependability

The idea of dependability emphasizes the need for the researcher to account for the ever-changing context within which research occurs (Trochim, 2006). The research is responsible for describing the changes that occur in the setting, and how these changes affected the way the researcher approached the study. To address the dependability issue more directly, the researcher has reported the processes within the study in detail, thereby enabling a future researcher to repeat the work.

4.6.8 Confirmability

Qualitative research tends to assume that each researcher brings a unique perspective to the study. Confirmability refers to the degree to which the results could be confirmed or corroborated by others (Trochim, 2006). The researcher has documented the procedures for checking and rechecking the data throughout the study.

4.7 ETHICAL CONSIDERATIONS

Koul (2008) explains that research ethics involves the development of guidelines that protect the rights of humans in research whereas Neuman (2003) insists that the researcher is morally and professionally obligated to be ethical irrespective of the participants' state of awareness of ethics or the lack thereof.

4.7.1 Ethical clearance by the university

Before the onset of the research, the researcher applied and obtained an ethical clearance certificate from the University of South Africa (see Appendix K).

4.7.2 Permission

The researcher sought the permission of the directors of each of the selected schools, in writing, to allow her to carry out the investigations in the selected schools before the research was conducted, and the board of all three schools granted permission (see Appendix L).

4.7.3 Informed consent and assent

Participants have the right to be fully aware of their involvement in a study and what would be expected of them. According to Cassell and Young (2002), informed consent is the cornerstone of ethical research. The researcher sought and confirmed the individual consent of the class six mathematics teachers before the research started. Primary six learners are considered minors since their ages are between 10 and 12. As a result, each learner was given a parental consent form which was completed and returned before the study began. Each learner also completed an assent form to confirm that apart from their parents giving their consent for them to participate in the study, they personally wanted to take part in the study. The forms contained detailed information about the purpose of the research, the procedure and what would be required of the participants (see Appendix M and N).

4.7.4 Privacy

The oral interviews were carried out in the private room assigned by each school, and the information given by the participants was not shared with anyone else to ensure the privacy of each participant.

4.7.5 Confidentiality

"In the context of research, confidentiality is the agreement to limit access to a subject's information," (Ethicist, 2015, p.100). The participants were assured of the confidentiality of their responses since the questionnaires for both the teachers and the learners did not include any column for names. In addition, only the researcher had access to answered questionnaires and the recorded interviews.

4.7.6 Anonymity

According to Walford (2005), researchers should give anonymity to research sites and the people involved in the research. To maintain anonymity, learners were assigned numbers which they wrote on their test papers instead of their names. In fact, a statement giving assurances to the respondents regarding the anonymity of the information they give was clearly posted in the introductory letter attached to the questionnaire and interview schedule (see Appendix O). By that, the research population was made sufficiently aware of the fact that they were merely the subject of this present study, and that their anonymity was assured.

4.8 CHAPTER SUMMARY

In this chapter, the researcher explained the research design O1–X–O2, which was the one group pre-test /post-test design used in this study to investigate the influence of mathematics vocabulary teaching on primary six learners' performance in geometry. To address the topic and seek to answer the research questions, a mixed-method approach involving the use of both qualitative and quantitative methods was employed. Three schools were involved in the study and quantitative data was collected through questionnaires for teachers and learners, and the results of the pre-test and post-test of learners' understanding of basic geometry. An intervention, which involved the teaching of geometry vocabulary to the learners, was carried out after the pre-test. The same test paper that was used for the pre-test was re-shuffled and re-administered to the learners as a post-test of learners' understanding of basic geometry, to see if the intervention had an impact. Finally, the researcher had a one-on-one interview with the seven participating teachers and 15 learners, five from each school; this is the qualitative component of the study. Data collected were quantitatively and qualitatively analysed, and the quantitative data obtained by the researcher was used to support qualitative data to effectively deepen the description of the study. The multi-method approach was discussed alongside the construction and administering of all the data collection instruments. Methods used to analyse data were also clearly outlined. The chapter concludes with discussions on the ethical considerations adopted in this study, such as ethical clearance by the university, informed consent, and assent, privacy, confidentiality, and anonymity.

CHAPTER 5: DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

5.0 INTRODUCTION

This chapter presents the results of the data collected through qualitative and quantitative methods to answer the research questions of the study. Firstly, quantitative data analysis of teachers' and learners' responses are discussed followed by the analysis of qualitative data of teachers' and learners' responses to the oral interview under each research question. Sections 5.1 to 5.4 present, analyse and discuss the findings of this study related to each research question in the same order as outlined below. A summary is provided at the end of each research question, and the chapter ends with some concluding remarks.

This study set out to answer the following research questions, as well as test the hypotheses outlined below:

a) What are the strategies used in the teaching of geometry in primary six in Ghanaian schools?

b) What are the teachers' perceptions of geometry vocabulary teaching?

c) How do primary six teachers in the selected Ghanaian primary schools teach geometry vocabularies?

d) How does the teaching of geometry vocabulary influence learners' performance in geometry?

   Null Hypothesis (H_0): There is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

   Hypothesis (H_1): There is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

The qualitative analysis of the oral interviews generated broad themes based on the responses of the participants. The broad themes are discussed under the appropriate research objective.

5.1 RESEARCH QUESTION 1

5.1.1 What are the strategies used in teaching geometry in primary six in Ghanaian primary schools?

Strategies used in the teaching of geometry as documented in the literature, include the following: the art of folding paper into plain shapes and solid objects - origami; hands-on activities, which include cutting out of 2-D shapes and making 3-D objects from paper, the use of manipulative materials, the use of geo-boards to make different shapes and figures, and the use of the environment to mention a few. During this study, learners and teachers were asked closed-ended questions to elicit the strategies used by the teachers to teach geometry. This was later followed by an oral interview of learners and teachers. Teachers' and learners' responses to questions 2, 3 and 4 in their respective questionnaires revealed that the following strategies were used by the teachers in teaching geometry: showing pictures of plain shapes and solid objects to learners, learners handling solid objects, teachers drawing diagrams of plain shapes and solid objects on the board, and teachers cutting-out plain shapes on paper for learners to visualize. Teachers and learners generally agree that they use the above strategies during geometry lessons. However, for some other strategies, such as learners practising by cutting-out plain shapes by themselves, teachers' showing videos of geometrical shapes to learners and learners being asked to imagine geometrical shapes during discussions, the learners do not have the same opinion as to the teachers. For these strategies, learners and teachers do not agree that they are used in the classroom. The above-named strategies are discussed in answering the research question one.

5.1.2 Strategy 1: Showing pictures of 2-D shapes and 3-D objects to learners

Table 5.1 shows the results of the analysis of questionnaire question 2 for learners, which states: "My teacher shows the class pictures of 2-D shapes and 3-D objects." Table 5.2 shows the result of the analysis of questionnaire question 2 for teachers, which states: "I show pictures of 2-D shapes and 3-D objects to learners." Both tables reveal that the strategy of showing pictures of plain shapes and solid objects to learners is a regular practice in the classroom. The importance of visualisation is well embedded in research (Arici & Aslan-Tutak, 2013; Delice & Tasova, 2011; Yoicu & Kurtulus, 2010). Delice and Tasova (2011) accentuate that visualisation in mathematics, which includes showing pictures of plain shapes and solid objects to learners, opens the door for learners' thinking in abstract geometry.

Pictures of geometrical 3-D objects such as cubes, cuboids, prisms, pyramids and their nets are shown to learners during geometry lessons. Most of these pictures are found in the textbooks used by both learners and teachers (see Appendix P, New Mathematics for Primary Schools, Pupils Book 6, p. 76-104). Learners and teachers agree that this practice is prevalent in the classroom as shown in Tables 5.1 and 5.2, and this finding agrees with findings in the literature (Daher & Jaber, 2010; Marchis, 2012) who maintain that learners understand the concept of plain shapes and solid objects better when they visualise them.

Table 5.1 Summary of learners' responses on being shown pictures of 2-D shapes and 3-D objects by the teacher

QN	Question	Responses	SA	A	N	D	SD	Total
2	My teacher shows the class pictures of 2-D shapes and 3-D objects	Respondents	113	75	24	27	11	250
		Percentage of responses	45.2	30.0	9.6	10.8	4.4	100.0

[see Appendix C]

In table 5.1, out of 250 learners, 113 (45.2%) and 75 (30%) strongly agreed and agreed respectively, to the use of pictures as a strategy the teachers use in the teaching of geometry, making a total of 188 (75.2%) of the learners who agreed. The use of pictures of 2-D shapes and 3-D objects enhances the understanding of the concept. For example, when a teacher uses the picture of a cuboid to teach learners the concept of the number of faces, edges and vertices of a cuboid, learners understand the concept better because using the picture, the teacher can guide learners to identify the faces, the edges and the vertices of the shape. Twenty-four (9.6%) learners were neutral in their responses, while 27 (10.8%) and 11 (4.4%) strongly disagreed and disagreed respectively to the construct. The fact that over 75% of the learners agreed to the construct is a clear indication that showing pictures of 2-D shapes and 3-D objects to learners by the teachers during geometry lessons is a regular practice in the classroom.

In the researcher's view, showing pictures of plain shapes and solid objects to learners when teaching geometry is a valuable strategy for geometry teaching. It does not only allow learners to understand the concepts better, but also affords them the possibility of being able to identify the plain shapes and solid objects in real life, and when they encounter them in other aspects of the school curriculum. For example, a learner who has seen the picture of a square-based pyramid during a geometry lesson will easily identify pyramids when learning about Egypt during a history or art class.

Clements and Battista (1999) and Clements (2003) support the use of pictures in the teaching of geometry, as they claim that it helps learners understand the concept better. It can, therefore, be concluded that showing learners pictures of geometrical shapes and objects during geometry lessons is deemed to be an important strategy used by participant teachers.

Table 5.2 Summary of teachers' responses to showing pictures of 2-D shapes and 3-D objects to learners

QN	Question	Responses	SA	A	N	D	SD	Total
2	I show pictures of 2-D shapes and 3-D objects to learners.	Respondents	4	3				7
		Percentage of responses	57.1	42.9				100.0

[see Appendix C]

Table 5.2 shows that all seven (100%) teachers concurred that they showed pictures of 2-D shapes and 3-D objects to learners. Most learners agree with all the teachers that the teachers show pictures of plain shapes and solid objects to learners during geometry lessons. The common use of this strategy by teachers in the teaching of geometry could be due to the availability of pictures of 3-D objects and their nets in most mathematics textbooks. For example, Primary Mathematics learners' book six, (page 74-81, see Appendix Q).

The use of the strategy of showing pictures of plain shapes and solid objects to learners was confirmed by both teachers and learners during the interview. One of the respondents said that the teacher brought solid objects to the class for learners to see and showed them how to count the number of faces, edges, and vertices. The learner added that the teacher brought pictures of solid objects such as cubes and cuboids to show them the properties of the objects for a better understanding of the concept. Below is what the respondent had to say;

"He brought us shapes to look at and showed us how many lines, edges, and vertices they had. He also taught us types of triangles. He brought pictures of solids such as cubes and cuboids to show us how many vertices they had for us to understand," (L9Q1).

One of the teacher respondents maintained that he started by showing learners charts containing shapes. These charts are pictures of solid objects. Next, he brings solid objects to class for learners to see and, as part of the class activity during the lesson, he involves learners in cutting out plain shapes in the class. Below is the direct response of the teacher;

"I start by showing the charts. Then we also use solid figures and cut out shapes as well. We involve the kids and get them as well," (T7Q1).

In the researcher's view, teachers and learners agree that showing pictures of solid objects is a well-grounded strategy for teaching geometry in class six, as revealed by the quantitative and qualitative findings, and both parties support its practice in the classroom. This finding supports the conclusions of Suydam and Higgins (1977) who maintain that the combined use of both manipulative materials and pictorial representations during lessons is highly effective. Learners and teachers used shapes and solids interchangeably, which is an indication that they are not aware of the correct vocabulary to use for 2-D shapes which are plain shapes and 3-D objects which are solid objects. Using the terms interchangeably reveals a lack of understanding of geometry vocabulary. If the teachers do not know the correct use of these vocabularies, how can they teach the learners?

5.1.3 Strategy 2: Learners handling solid objects

The responses of learners and teachers to the close-ended question regarding handling of solid objects by learners as a strategy for teaching geometry is reported below.

Table 5.3 Summary of the responses of learners to "our teacher gives us solid objects to handle"

QN	Question	Responses	SA	A	N	D	SD	Total
3	Our teacher gives us solid objects to handle.	Respondents	71	61	30	72	16	250
		Percentage of responses	28.4	24.4	12.0	28.8	6.4	100.0

[See Appendix C]

Tables 5.3 shows learners' responses to the question regarding handling solid objects in the classroom as a method of teaching geometry. Seventy-one (28.4%) and 61 (24.4%) out of a total of 250 learners, strongly agreed and agreed to the construct, while 30 (12.0%) were neutral. Also, 72 (28.8%) and 16 (6.4%) disagreed and strongly disagreed respectively. From the findings, 52.8% of the learners were positive about the handling of solid objects such as cubes, cuboids, prisms, pyramids, trapeziums, cones, football, etc. during geometry lessons. However, 35.2% did not agree that the teachers give them solid objects to handle, and 12% of the learners were neutral to the construct. The 30 learners who were neutral were unsure about their teacher giving them solid objects to handle during geometry lessons and as a result decided to sit on the fence. In my opinion, it is very likely that these learners were not given solid objects to handle during geometry lessons as the experience of manipulating solid objects during geometry lessons may not be easily forgotten, since such fun activities are not very common during mathematics lessons.

Aslan-Tutak and Adams (2017), Marchis (2012) and Daher and Jaber (2010) found the use of hands-on activities very useful and meaningful in teaching geometry to pre-service teachers. The pre-service teachers were in favour of this strategy in the teaching of geometry as they found it applicable to real life. Pre-service teachers found the handling of solid objects interesting as it made the lessons more enjoyable and interactive. From the experience of handling the solid objects, the pre-service teachers could relate to the 2-D shapes that make up the faces of the objects and find their properties. In addition, this strategy assists learners to recognize figures by their global appearance rather than by identifying significant features. For example, a rectangle can easily be recognised by learners because it looks like a door. The use of the strategy of handling solid objects during geometry lessons is crucial, as learners learn better if they move from handling solid objects such as cones and cylinders to abstract visualization.

Clements and Battista (1992) clearly state that the use of manipulative materials which includes handling of solid objects during geometry teaching improves learners' understanding of geometry, as it plays a major role in enhancing the geometric reasoning skills of learners, and creates a suitable context that allows transition from empirical thinking to more abstract thinking. This demands that teachers should endeavour to give learners solid objects such as cylinders, cones, pyramids etc. to handle during geometry lessons to enable learners have first-hand experience with the objects and their properties, gain mastery of the concept, relate it to real life and as a result, develop an interest in the study of geometry in particular, and mathematics in general. This practice will also help learners' ability to retain and recall geometrical facts and in turn, reduce learners' fear of mathematics.

Table 5.4 Summary of the responses of Teachers to giving learners solid objects to handle

QN	Question	Responses	SA	A	N	D	SD	Total
3	I give my learners solid objects to handle	Respondents	4	2	1			7
		Percentage of responses	57.1	28.6	14.3			100.0

[see Appendix C]

Tables 5.4 presents teachers' responses to the question regarding handling solid objects in the classroom as a method of teaching geometry. Six teachers out of seven, totalling 85.7% agreed to the use of this strategy in the teaching of geometry. However, one teacher out of seven (14.3%) was neutral about this practice in the classroom.

The fact that only 52.8% (see Table 5.3) of the learners were positive about handling solid shapes in the classroom is an indication that although this strategy is used in the classroom, it may not be used frequently by the teachers, as a high percentage of the learners either disagreed or were neutral. In addition, one teacher was neutral (see Table 5.4) about the construct. For a teacher to be unsure or neutral about using a strategy in class implies that the teacher probably does not use the strategy, but does not want to admit to the lack of its practice in the classroom.

Still under the "strategies used to teach geometry in Ghana", some of the respondents stated during the interview that teachers brought in wooden 3-D objects to class to show learners the properties of solid objects such as edges, angles, vertices, number of parallel sides, faces, etc., and some of the teachers emphasised the importance of handling 3-D objects in the classroom during a geometry lesson. Below are some of the responses by both learners and teachers during the interview.

"Our teacher brought in wooden 3-D shapes to demonstrate and show us lines and angles…," (L8Q1).

"I see geometry to be a very practical subject in every area of life, so I think there is the need for us to "practicalise" it in the classroom. We use cut-outs, cardboards where the learners will also be involved in it and make the lesson very interesting and easy," (T1Q1).

"I believe that using the solid object, they get an understanding of the concept better," (T3Q2).

"For primary 6 learners, geometry can look very abstract to children at that level and so we try as much as possible to come down to their level. We have to show the diagrams to demonstrate. For instance, to demonstrate angles as where two lines meet, you can use two sticks or something to join together and show the space where the angle is formed and that will make it easier…." (T4Q1).

These respondents explain that the use of hands-on activities make geometry lessons interesting, easier to understand, and it connects learners with mathematics in the environment. Furthermore, some of the respondents added that:

"Sometimes he brings shapes and shows to us in the class. He shows us the edges, the vertices and faces and tests us later. He gives notes also," (L10Q1).

"He brought shapes to class and involved us in identifying the angles, edges, and faces," (L15Q1).

The above quotes by learners and teachers indicate that they concur with the handling of solid objects. The experience of handling solid objects during geometry lessons gives learners invaluable and rich first-hand experiences. This goes a long way to consolidate the learning of geometry. Quantitative and qualitative findings confirm that teachers give solid objects to learners to handle and encourage learner participation during geometry lessons. This finding is in line with the findings of Suydam and Higgins (1977) that affirm that learners have a higher probability of achieving better grades in mathematics if the teachers used manipulative materials during lessons.

5.1.4 Strategy 3: Teachers draw diagrams of 2-D shapes and 3-D objects on the board for learners to see

The summary of the learners' and teachers' responses to whether teachers draw diagrams of 2-D shapes and 3-D objects on the board for learners to see is presented below.

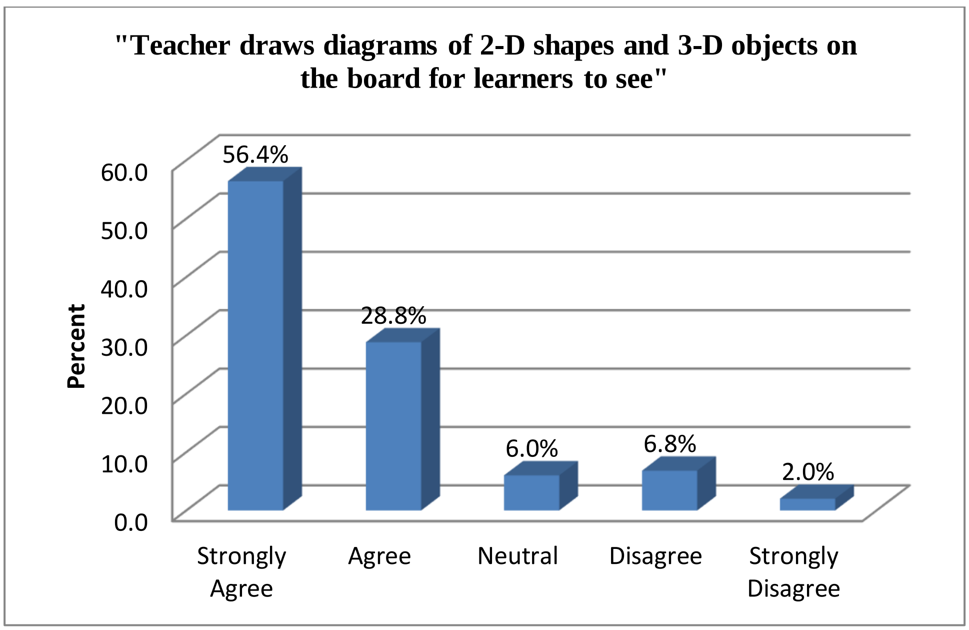


Figure 5.1 **Bar chart showing learners' responses on teachers drawing diagrams of 2-D shapes and 3-D objects on the board for learners to see**

One hundred and forty-one (56.4%) and 72 (28.8%) (see Appendix M and Figure 5.1) of the learners strongly agreed and agreed respectively, that teachers drew diagrams of 2-D shapes and 3-D objects on the board for them to see. Also, 15 (6%) of the learners were neutral while 17 (6.8%) and 5 (2%) disagreed and strongly disagreed respectively to this construct (see Fig 5.1).

Table 5.5 Summary of teachers' responses to drawing diagrams of 2-D shapes and 3-D objects on the board for learners to see

QN	Question	Responses	SA	A	N	D	SD	Total
4	I draw diagrams of 2-D shapes and 3-D objects on the board for the learners to see.	Respondents	7					7
		Percentage of responses	100.0					100.0

[see Appendix C]

Table 5.5 reveals that all seven teachers (100%) affirm that they draw diagrams of 2-D shapes and 3-D objects on the board for the learners to see. This was confirmed by the learners as 85.2% of the learners concurred to the construct (see Figure 5.1). This strategy is the most popular among the teachers, most likely because it is closely related to the traditional method of teaching, which is more of lecture method, so the teacher draws the shape on the board and lectures about the shape. Research shows that most mathematics teachers use the teacher-centred mode of teaching (Ampiah, Akyeampong & Leliveld, 2004; Mereku, 2010). Teachers teach mathematical concepts, principles and algorithms in a casual and non-committal manner, while learners were observed to learn under a rather passive and fearful condition (Mereku, 2010). This method of teaching does not encourage learners' participation; teachers simply lecture learners with the learners making little or no contribution. The method of drawing shapes on the board can, however, be enriched if teachers together with the learners draw the 2-D shapes and the 3-D objects on the board and engage learners in deep meaningful discussions regarding the plain shapes and solids. This, in contrast to the lecture method, will provide elaborate and memorable learning experiences for the learners (Mereku, 2010).

The learners and teachers responded as follows regarding the use of this strategy during the teaching of geometry in the interview:

"He sometimes gives us examples or draws them on the board and gives their meanings. He sometimes draws them and labels the parts as well," (L7Q1).

"He sometimes drew them. He shows us shapes, edges, vertices and faces," (L14Q1).

"My teacher draws the shapes on the board and writes the numbers of the perimeter and area then we are asked to find the perimeter and the area. After that, we do angles of shapes and we learn about lines and angles," (L5Q1).

"……. But when it comes to lines, angles and so on, I use drawings most often and…," (T3Q1).

These respondents explain that teachers draw lines, plain shapes, and angles on the board. The act of drawing to depict what is being taught in geometry is a common practice in the classroom. In addition, some other respondents had this to say:

"He also drew diagrams that were showing lines and angles on the board. He took us to the maths and science facility to show us lines and angles. He made us point to lines and angles in the classroom," (L3Q1).

"We can draw some of them either on the board for them to copy or we can also use the manila card where we do some sketches on it for the learners to see and observe them very well…," (T2Q1).

Data from quantitative and qualitative sources confirm that both teachers and learners agree that the teachers draw diagrams of 2-D shapes on the board for learners to see. The results reveal that drawing is a regular activity during geometry lessons and learners were sometimes involved in identifying lines and angles in the environment.

5.1.5 Strategy 4: Teachers cut out plain shapes for learners

In response to the question of whether teachers cut out plain shapes on paper for the learners to visualize, table 5.6 and 5.7 show the summary of the responses of the study participants.

Table 5.6 Summary of learners' responses to teacher cuts out plain shapes for learners to visualize

QN	Question	Responses	SA	A	N	D	SD	Total
5	Our teacher cuts out plain shapes on paper e.g. squares, rectangles, triangles etc. for us to visualize.	Respondents	56	51	33	82	28	250
		Percentage of responses	22.4	20.4	13.2	32.8	11.2	100.0

see Appendix C]

In table 5.6, out of 250 learners, 56 (22.4%) strongly agreed while 51 (20.4%) agreed to this construct. Thirty-three (13.2%) of the learners were neutral in their responses to this construct, while 82 (32.8%) and 28 (11.2%) disagreed and strongly disagreed respectively to the construct (see Table 5.6). The implication is that 57.2% of the learners, which is more than half the population of the participating learners, were not in support that their teachers cut out plain shapes on paper for them to visualize when teaching geometry.

The oral interview revealed that only one learner out of the fifteen interviewed mentioned that teachers cut out shapes for learners during geometry lessons. The learner's response is reported below:
"Sometimes, he gets the methods on the board. He cuts out some shapes then he uses the cards which are like shapes; the squares, rectangles, etc. he sometimes draws the images and the figures on the board and teaches us what we need to do," (L6 Q1).
The learner above confirmed that teachers cut out shapes and used cards of specific shapes during geometry lessons. For example, if the teacher cuts out rectangular cards to show rectangles, hexagonal cards to show hexagons, octagonal cards to show octagons and so on, that experience would stay with learners for a very long time. For only one learner to testify to the use of this strategy during the interview raises doubts that teachers use this strategy during geometry lessons.

The teachers' responses to cutting out plain shapes for learners to visualize is reported below.

Table 5.7 Summary of teachers' responses to cutting out plain shapes for learners to visualize

QN	Question	Responses	SA	A	N	D	SD	Total
5	I cut out plain shapes on paper, e.g. rectangles, squares, triangles, etc. for learners to visualize.	Respondents	2	3		1	1	7
		Percentage of responses	28.6	42.8		14.3	14.3	100.0

[see Appendix C]

In table 5.7, two (28.6%) and three (42.8%) teachers strongly agreed and agreed respectively, to cutting out shapes on paper for learners to visualize, while 14.3% and another 14.3% disagreed and strongly disagreed respectively, to the use of this strategy. This shows that a total of 71.4% of the teachers claim to cut out plain shapes on paper for learners to visualize when teaching geometry.
The learners and teachers are in disagreement over the use of this strategy in the classroom as over 70% of the teachers attest to cutting out plain shapes on paper for learners to visualize when teaching geometry, but only 42.8% of the learners agreed (see Tables 5.6 and 5.7). This is an indication that the use of this strategy in the classroom is not consistent, since more than half of the learners were either neutral in agreement with the construct or did not agree. Some of the teachers themselves disagreed about cutting out plain shapes for learners to visualize. In the researcher's opinion, this implies that the practice is inconsistent in the classroom. Perhaps some teachers actually cut out plain shapes on paper for learners to visualize during geometry lessons, while others do not use this strategy at all.
The responses of some teachers to the oral interview on how they teach geometry are reported below:

"I see geometry to be a very practical subject in every area of life, so I think there is a need for us to praticalise it in the classroom. We use cut-outs, cardboards where the learners will also be involved in it and make the lesson very interesting and easy," (T1Q1).

"If I take specifically shapes, I use paper cut out shapes and bring them to class. I use sticks and brooms to represent lines. I break them to form angles, short and long lines, and form shapes like triangles with them as well. I use these practical ideas to teach them before showing them the figure of a triangle…," (T5Q11).

Although teachers are positive that they cut out plain shapes for learners, less than 50% of the learners agreed to this claim. There is evidence from both quantitative and qualitative results that the teachers cut out shapes for learners to see and probably handle during geometry lessons, but whether it is a common practice or not, it is in dispute, as more than half of the learners did not confirm the actual use of this strategy in the classroom.

5.1.6 Strategy 5: Learners cut-out plain shapes

The summary of learners' responses to the closed question on teachers asking learners to cut out shapes during geometry lessons is reported below.

Table 5.8 Summary of learners' responses to teacher asking learners to cut out plain shapes on paper

QN	Question	Responses	SA	A	N	D	SD	Total
6	Our teacher asks the learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.	Respondents	19	40	36	105	50	250
		Percentage of responses	7.6	16.0	14.4	42.0	20.0	100.0

[see Appendix C]

Table 5.8 shows that 19 (7.6%) and 40 (16%) strongly agreed and agreed respectively, that their teachers asked them to cut out plain shapes on paper during geometry lessons. However, 36 (14.4%) of the learners were neutral, while 105 (42%) and 50 (20%) disagreed and strongly disagreed to the use of this strategy in their classes. The findings reveal that 76.4% of the learners did not agree with this construct. This has implications regarding the actual use of this strategy in the classroom.

The lack of adequate use of this practice in the classroom was confirmed during the oral interview as no learner made mention of teachers asking learners to cut out plain shapes during geometry lessons. However, a few learners mentioned that teachers cut out shapes for them, as earlier revealed. It can be concluded that teachers cut out plain shapes for learners, but they do not ask learners to carry out the activity. If they do, then it is not a strategy that is commonly used during geometry lessons.

Table 5.9 presents the summary of teachers' responses to the closed question on teachers asking learners to cut out shapes during geometry lessons.

Table 5.9 Summary of teachers' responses to learners cut out plain shapes on paper

QN	Question	Responses	SA	A	N	D	SD	Total
6	I ask my learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.	Respondents	2	3	2			7
		Percentage of responses	28.6	42.8	28.6			100.0

[see Appendix C]

Table 5.9 shows that two (28.6%) and three (42.8%) of the teachers strongly agreed and agreed respectively, to asking learners to cut out shapes on paper as a strategy for teaching geometry while two (28.6%) were neutral. The results reveal that five out of seven teachers indicated it to be a strategy they employed for teaching geometry; that is, they asked their learners to cut out plain shapes, but more than half of the learners did not agree that this practice being adopted in class during geometry lessons. The responses of three teachers to the oral interview are reported below:

"I make them do the cut-outs and we mould them to form the shapes with glues and adhesive tapes. Since it is activity-based, I go around and supervise. I correct where necessary," (T6Q2).

"We have a lot of hands-on activities. Like I said earlier we use a lot of cut-outs and the children will also be involved in the cutting," (T1Q2).

"…They can also cut out shapes using the cardboard. We bring them together and study the shapes and their parts," (T4Q2).

As observed above, one of the teachers used shapes to mean solid object, indicating a lack of understanding of appropriate geometry vocabulary. The qualitative and quantitative results for the teachers regarding this construct reveal that teachers ask learners to cut out shapes during geometry lessons. However, table 5.8 shows that over 75% of the learners do not attest to being asked to cut out plain shapes on paper by their teachers. This can be considered as a case of wish and actual practice. There is a possibility that some of the teachers do not use this strategy at all during geometry lessons and, maybe, the teachers that use it only do so occasionally.

5.1.7 Strategy 6: Teachers show videos of geometrical shapes and figures to learners

Table 5.10 present learners' responses on watching videos of geometrical shapes and figures as a strategy used by their teachers in the teaching of geometry.

Table 5.10: Summary of the learners' responses to watching videos of geometrical shapes and figures

QN	Question	Response	SA	A	N	D	SD	Total
7	We watch videos of geometrical shapes and figures.	Respondents	6	9	16	107	112	250
		Percentage of responses	2.4	3.6	6.4	42.8	44.8	100.0

[see Appendix C]

Table 5.10 reveal that only six (2.4%) and nine (3.6%) learners out of 250 learners strongly agreed and agreed respectively, to watching videos of geometrical shapes and figures during geometry lessons. One hundred and seven (42.8%) and 112 (44.8%), totalling 87.6% of the learners disagreed and strongly disagreed respectively to watching videos of geometrical shapes and figures while 16 (6.4%), were neutral to the construct. This clearly indicates that learners do not watch videos during geometry lessons because if it was an actual practice in the classroom, more learners would have remembered and attested to it.

The results on teachers' responses to showing learners videos as a strategy of teaching geometry is reported below.

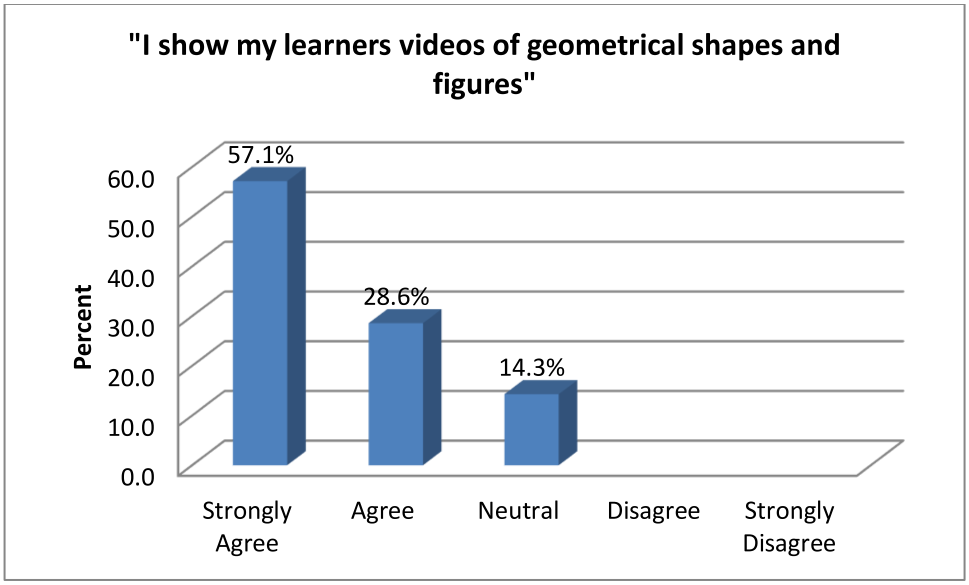


Figure 5.2 **Bar chart showing teachers' responses on learners' watching videos of geometrical shapes**

Figure 5.2 reveals that a total of six out of seven teachers, making 85.7% of the teachers indicated that they showed videos of geometrical shapes and figures to the learners during geometry lessons. However, the results from the learners reveal that only a small 6% of the learners agreed to have watched videos during geometry lessons. This is a clearer case of inconsistency.

The results of the oral interview of learners and teachers corroborate the results of the learners from the quantitative data, as no learner or teacher mentioned watching or showing videos as a strategy for teaching geometry when they were asked.

It can be concluded that teachers believe that learners should be shown videos of geometrical shapes and figures during geometry lessons, but they do not practise it in the classroom. This could be due to several reasons ranging from lack of equipment to lack of time, resources and inadequate infrastructure, to mention a few (Bingimlas, 2009; Ghavifekr, Kunjappan, Ramasamy & Anthony, 2016). The huge contrasts between the claim of the teachers and the learners, however, are worth noting. What could be the cause of this disparity? In my opinion, it could be because teachers know the benefits of the use of this strategy and as a result, insist that they show learners videos of geometrical shapes and figures rather than state the truth as the truth may make them appear incompetent.

5.1.8 Strategy 7: Teachers ask learners to imagine shapes

Table 5.11 reports the summary of learners' responses to whether their teachers ask them to imagine geometrical shapes during discussions, or not.

Table 5.11 Summary of learners' responses to "our teacher asks us to imagine geometrical shapes"

QN	Question	Response	SA	A	N	D	SD	Total
8	Our teacher asks us to imagine shapes and figures during discussions.	Respondents	35	46	33	76	60	250
		Percentage of responses	14.0	18.4	13.2	30.4	24.0	100.0

[see Appendix C]

In table 5.11, out of a total of 250 learners, 35 (14.0%) of the learners strongly agreed, 46 (18.4%) agreed, 33 (13.2%) were neutral, and 76 (30.4%) disagreed to the construct. Sixty (24.0%) strongly disagreed that their teachers asked them to imagine shapes during geometry lessons and discussions. The results indicated that more than two-thirds of the learners did not agree that the teachers used this strategy.

Table 5.12 reports the summary of teachers' responses to whether they ask learners to imagine geometrical shapes during discussions.

Table 5.12 Summary of teachers' responses to "I ask my learners to imagine 2-D shapes and 3-D objects"

QN	Question	Response	SA	A	N	D	SD	Total
8	I ask learners to imagine 2-D shapes and 3-D objects during discussions.	Respondents	1	1	1	3	1	7
		Percentage of responses	14.3	14.3	14.3	42.8	14.3	100.0

[see Appendix C]

In table 5.12, 14.3% of the teachers strongly agreed, another 14.3% also agreed that they asked learners to imagine 2-D shapes and 3-D objects during discussions. However, 14.3% were neutral, and another 14.3% strongly disagreed respectively, that they asked learners to imagine plain shapes and solid objects during discussions. Three out of the seven teachers totalling 42.8% disagreed to the construct.

The findings indicate that fewer learners (32.4%) (see Table 5.11) and teachers (28.6%) (see Table 5.12) support the use of this strategy during geometry lessons. In the researcher's opinion, there is a possibility that alongside using some of the other strategies discussed previously, some teachers ask learners to imagine shapes during discussions. It may not be a core strategy employed in the teaching of geometry, but this strategy can be used to create a vivid mental image or picture of geometrical shapes and objects in the minds of learners. However, for this strategy to have a positive impact, it should only be used after the learners have become familiar with the geometrical shapes and objects from seeing and handling them consistently over an appreciable period.

The findings from the oral interview of teachers and learners support the result above, as no teacher or learner mentioned imaging plain shapes and solid objects as a strategy for teaching geometry. However, the appropriate use of this strategy during the later stages of geometry lessons could have a positive mental impact on learners' understanding of geometry, as it could help learners visualise geometrical shapes and solids mentally.

5.1.9 Conclusion to research question 1

Regarding research question 1, the findings reveal that teachers show learners pictures of 2-D shapes and 3-D objects as a strategy of teaching geometry, and they also bring solid objects to class for learners to visualize. In addition, teachers draw diagrams of 2-D shapes and 3-D objects on the board for learners to see and teachers cut out plain shapes on paper for learners to visualize. Although the results showed that teachers cut out plain shapes for learners to see, the quantitative and qualitative findings could not ascertain that teachers asked learners to cut out plain shapes by themselves (see Table 5.8 and Table 5.9). The learners did not agree that they were asked to cut out plain shapes such as kites, triangles, squares and rectangls by their teachers during geometry lessons.

The results further show that the drawing diagrams of 2-D shapes and 3-D objects on the board is the most common strategy used in the teaching of geometry, followed by the use of pictures and charts. The findings indicate that handling of solid objects and hands-on activities make geometry lessons interesting, and help learners understand the concept of geometry better. This affirms research by Aslan-Tutak and Adams (2017), as pre-service teachers were positive on the effectiveness of using visual aids such as drawings for their geometry learning.

Interestingly, although 85.7% of the teachers claimed to show the learners' videos of geometric shapes from the analysis of the teachers' questionnaire, the learners did not share the same view. To confirm the lack of use of this strategy in the classroom, no learner or teacher referred to watching videos as a strategy used in teaching geometry during the oral interview. It can, therefore, be concluded that showing videos of geometrical shapes and figures was not practised consistently in the classroom as a strategy for teaching geometry in the selected schools whereas the use of this strategy could make the learning of geometry fun and stimulate learners' interest which could lead to better performance in geometry.

5.2 RESEARCH QUESTION 2

5.2.1 What are the teachers' views on geometry vocabulary teaching?

Research question 2 was answered using both qualitative and quantitative data. To find the perceptions of teachers on geometry vocabulary teaching, a questionnaire and interview guide were employed. Questions 10 – 13 of the teachers' questionnaire were focused on the teachers' perception of geometry and mathematics vocabulary teaching to find their perception. Teachers were asked whether they understood the concept of geometry and mathematics vocabulary teaching, and if they emphasised geometry and mathematics vocabulary as well as if they taught geometry and mathematics vocabulary. The analysis of the teachers' questionnaires (see Table 5.13 below) showed that the constructs measuring the teachers' perception about the teaching of mathematics and geometry vocabulary fairly correlated with each other (inter-item correlation = 0.331, p-value = 0.00).

Statistically, it means that for these teachers, one construct can be used in the absence of the other for the views expressed, since it indicates a positive relationship between the constructs. The average response to all 18 constructs is approximately '2', indicating that the teachers overwhelmingly agreed to various constructs shared in the teaching of mathematics and geometry vocabulary in primary six. The summary of the teachers' responses to all the constructs regarding the teaching of mathematics and geometry vocabulary is shown below.

Table 5.13 Summary of teachers' perceptions regarding the teaching of mathematics and geometry vocabulary

QN	Question	Response	SA	A	N	D	SD	Total
10	I know and understand the concept of mathematics vocabulary teaching.	Respondents	4	3				7
		Percentage of responses	57.1	42.9				100.0
11	I lay emphasis on the teaching of geometry vocabulary.	Respondents	1	4	2			7
		Percentage of responses	14.3	57.1	28.6			100.0
12	Mathematics vocabulary should be taught in schools.	Respondents	7					7
		Percentage of responses	100.0					100.0
13	Geometry vocabulary should be taught in schools.	Respondents	7					7
		Percentage of responses	100.0					100.0

[see Appendix C]

The findings reveal that four (57.1%) and three (42.9%), totalling seven (100%) of the teachers strongly agreed and agreed respectively, that they know and understand the concept of mathematics vocabulary teaching. Furthermore, all seven teachers, representing 100% strongly agreed that mathematics vocabulary and geometry vocabulary ought to be taught in schools. They all recommended the teaching of mathematics and geometry vocabulary in schools, as they maintained that the teaching of such vocabulary would enhance learners' performance in geometry in particular and mathematics in general. However, regarding laying emphasis on the teaching of geometry vocabulary, two of the seven teachers were neutral to the construct, implying that they were unsure of the role of mathematics and geometry vocabulary teaching on learners' performance in mathematics and geometry.

Learners also supported the teaching of mathematics vocabulary. The summary of their responses to this construct is reported below.

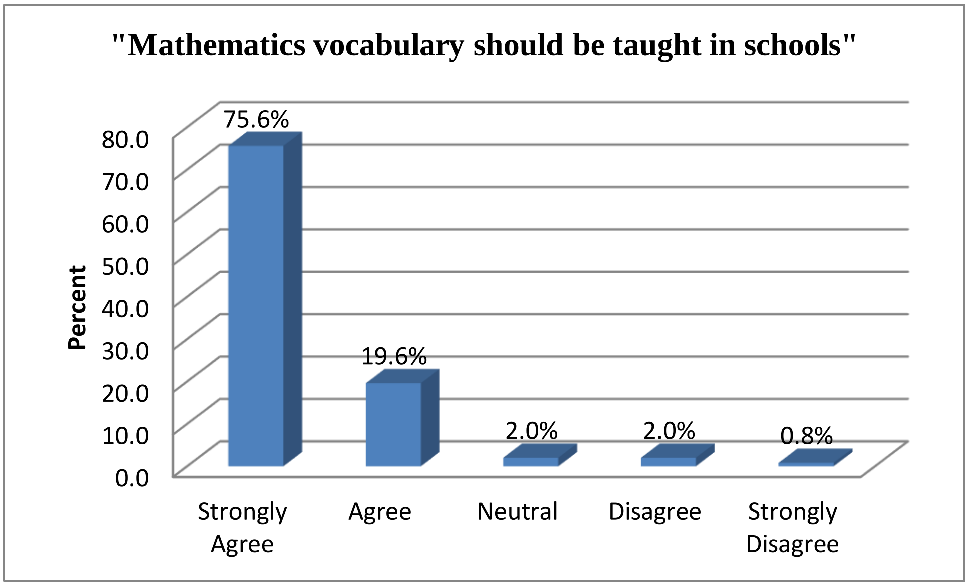


Figure 5.3 **Bar chart showing learners' responses on the teaching of mathematics vocabulary**

The findings show that 75.6% and 19.6%, totalling 95.2% of the learners strongly agreed and agreed respectively, that mathematics vocabulary ought to be taught in schools. However, five learners making up 2% of the learners were neutral in their responses to the construct, while another 2% and 0.8% disagreed and strongly disagreed respectively, to the construct. From the findings, only an insignificant 4.8% of the learners did not support the teaching of mathematics vocabulary in schools (see Figure 5.3 above). The results showed that learners and teachers mainly supported the teaching of mathematics vocabulary.

In response to teachers' and learners' interview questions: *"What is your understanding and perception of the concept of geometry vocabulary teaching?" and "How frequently should mathematics vocabulary be taught in school and why?"* two themes emerged, namely the importance of geometry vocabulary teaching, and frequency of mathematics vocabulary teaching.

5.2.2 Theme 1: Importance of geometry vocabulary teaching

The importance of geometry vocabulary teaching featured prominently in the teachers' responses. They all concurred that the teaching of geometry vocabulary is important as it will help learners understand the concept of geometry better. One of the teachers said:

"I think it is a very important key you can't do away with that. Without it, I believe the learners will be at sea because even for us adults, it's a bit challenging to understand the concept of geometry

without understanding the vocabulary associated with the topic. So, I believe it is very necessary," (T4Q5).

Apart from being important, some teachers added that the teaching of geometry vocabulary would assist learners to apply geometry to everyday life. For example, if learners knew the meaning of a right angle, a pentagon, a circle, a prism, etc. they would identify these shapes in the environment, making learning more meaningful. In addition, the teaching of geometry vocabulary makes the learning of geometry easy and lively as expressed below by two respondents.

"I think like any other topic or most of the topics in mathematics; it is a lifelong lesson that one must learn. Therefore, I believe that children should be taught very well to understand it so that they can apply it in their everyday life in the future," (T3Q5).

"One thing you must know is that, before the children will be able to understand the topic or subject very well, they must know the vocabulary around that particular topic. So, I share the idea that we must teach the learners the vocabulary in the subject to understand it in the subject. We must also explain further for the children to understand the concepts we discuss behind the whole thing, so it becomes easier and very lively when it is time to learn the subject," (T2Q5),

As expressed in the words of one of the teachers above and two teachers below, they maintained that content vocabulary teaching was the foundation of the subject, and that teaching the vocabulary of a particular subject made the subject easy to understand and learners lively. Lively because they could connect with the subject due to adequate understanding.

This implies that without the teaching of geometry vocabulary, understanding geometry may be challenging for learners as they may not comprehend the subject.

"The vocabulary is the foundation of the whole subject, so I teach them as and when necessary," (T7Q5).

"If you don't know the words used in a certain field, you cannot understand it. I personally don't teach it in isolation; I use it when I'm teaching. When it comes to lines, segments, radius, and diameter, it comes in when I'm teaching, and I emphasize on them so that they will use it to identify the objects," (T5Q5).

The findings reveal that the teachers believe that content vocabulary teaching helps in learners' understanding and concept application. This finding is supported by the study of Beck, McKeown and Kucan (2002) who explain that understanding the vocabulary is closely related to conceptual understanding and that teachers should place more consideration on words' usefulness and frequency of use. In addition, the results reveal that mathematics vocabulary teaching makes the subject lively and easy to understand. This study shows that teachers and learners believe that geometry vocabulary teaching will enhance learners' understanding of geometry, help learners apply the concept of geometry to everyday living and make geometry learning easier and more interesting that will, in turn, translate to enhanced performance in geometry. For example, a question as simple as being asked to identify the parallel lines and perpendicular lines in a class test can become a challenging and very difficult question for a learner who does not know the meaning of parallel and perpendicular. In contrast, a learner who understands the vocabulary and knows the meaning of parallel and perpendicular will find that test very easy. This is in agreement with Fabricius who maintains that without adequate knowledge of mathematics vocabulary, learners may find it difficult to answer mathematical questions, even if they understand the associated concepts and procedures (Fabricius, 2012).

5.2.3 Theme 2: Frequency of geometry vocabulary teaching

The learners unanimously agreed that mathematics vocabulary ought to be taught frequently. Some learners went on to say that mathematics vocabulary ought to be taught every day. Here are some of the learners' responses:

"Mathematics vocabulary should be taught every day," (L1Q4).

"Every day; because it gives more understanding about the concepts we learn," (L2Q4).

Acquisition of application skills, speed and easy understanding of mathematics are some of the reasons for which learners advocate for frequent teaching of mathematics vocabulary.

These were expressed by some of the learners below.

"It has to be taught frequently because it helps learners. When the teacher is about to teach the subject, it makes it easier for learners to understand," (L3Q4).

"It should be taught very often so that children will know mathematics very fast and it will also be easier for them," (L4Q4).

"Mathematics vocabulary should be taught every day because we need to apply them when the need arises," (L11Q4).

"Every day, because I know that when we are taught the geometry vocabularies, it will make the learning of maths easier," (L12Q4).

The responses revealed that all the teachers and learners had a positive perception of the teaching of mathematics and geometry vocabulary. The interviewed learners and teachers agreed that mathematics and geometry vocabulary ought to be taught in schools frequently.

5.2.4 Conclusion to research question 2

Regarding research question 2, the findings from the quantitative and qualitative results reveal that both teachers and learners totally agree concerning the teaching of mathematics and geometry vocabulary. Some of the respondents added that mathematics vocabulary, particularly geometry vocabulary, ought to be taught daily during mathematics and geometry lessons, claiming that it would make mathematics easier and help learners understand the subject better. The findings of this study regarding the teachers' and learners' perception on the teaching of geometry vocabulary are in tandem with the findings of Güner and Gülten (2016) and Toptas (2015), who state that since geometry is a crucial aspect of mathematics, the use of mathematics language in geometry is extremely important.

Important in the sense that mathematics vocabulary plays a crucial role in the building of sound concepts and subsequent development of mathematical thinking according to Güner and Gülten (2016) and success in mathematics teaching is directly related to the accurate use of mathematics vocabulary (Güner & Gülten, 2016; Ferrari-Luigi, 2004; Raiker, 2002; Barton, Heidema & Jordan, 2002; Lee & Herner-Patnode, 2007).

5.3 RESEARCH QUESTION 3

5.3.1 How do primary six teachers in the selected Ghanaian primary schools teach geometry vocabulary?

The responses of learners and teachers regarding this question showed varied opinions on the teaching of geometry vocabulary.

The learners' responses to having been taught geometry vocabulary is reported below.

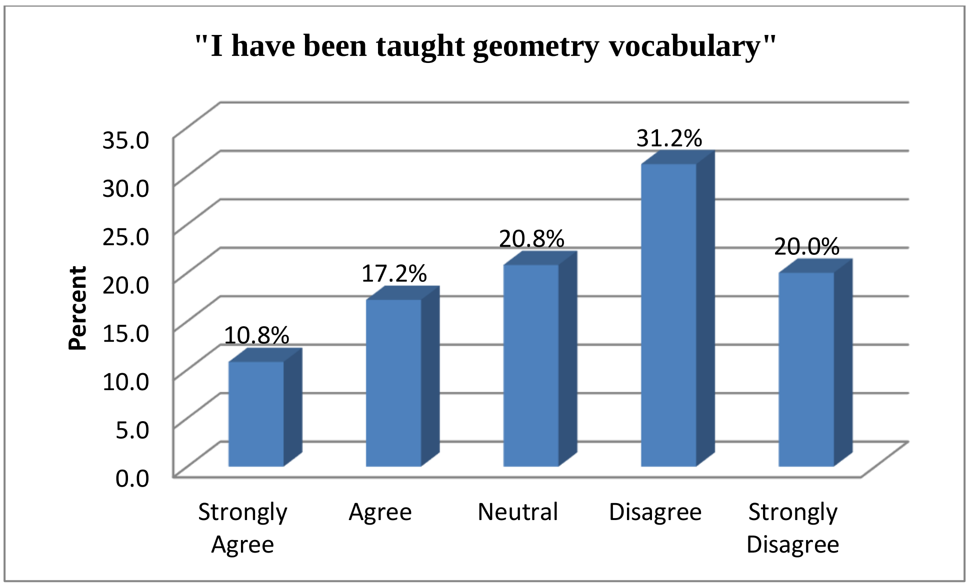


Figure 5.4 **Bar chart showing views of learners on the teaching of geometry vocabulary**

Only 10.8% of the learners and 17.2% making a total of 28% of the learners strongly agreed and agreed respectively, to having been taught geometry vocabulary. The remaining 72% were either neutral or disagreed to the construct. In the researcher's opinion, there might be a mention of geometry vocabulary from time to time during geometry lessons as the learners encounter the new words. However, the actual in-depth teaching of the vocabulary may not necessarily take place, as more than 70% of the learners could not attest to being taught geometry vocabulary during geometry lessons.

Table 5.14 Summary of learners' response regarding geometry vocabulary teaching

QN	Question	Response	SA	A	N	D	SD	Total
10	I understand what I was taught in geometry vocabulary.	Respondents	25	40	48	89	48	250
		Percentage of responses	10.0	16.0	19.2	35.6	19.2	100.0
11	I remember almost all that I was taught in geometry vocabulary.	Respondents	17	28	58	91	56	250
		Percentage of responses	6.8	11.2	23.2	36.4	22.4	100.0
12	I can answer any question asked on geometry vocabulary.	Respondents	9	30	78	80	53	250
		Percentage of responses	3.6	12.0	31.2	32.0	21.2	100.0

[see Appendix C]

The learners were consistent in their responses regarding the teaching of geometry vocabulary, their understanding, their ability to remember what they have been taught in geometry vocabulary, and their ability to answer questions asked on geometry vocabulary. Most of the learners, over 75% were either neutral in their responses, disagreed or strongly disagreed to all three constructs. These learners were not confident enough to establish the teaching of geometry vocabulary in the classroom. If geometry vocabulary teaching was a consistent activity during mathematics or geometry lessons, more learners would have been able to confirm its practice. It can, therefore, be argued that the teachers did not teach geometry vocabularies during geometry lessons and since the vocabularies were not taught, learners could not explain or describe how the teachers taught geometry vocabulary, and this was understandable.

The summary of the teachers' responses to the questionnaires is reported below.

Table 5.15 Summary of teachers' responses to laying emphasis on the teaching of geometry vocabulary

QN	Question	Response	SA	A	N	D	SD	Total
11	I lay emphasis on the teaching of geometry vocabulary.	Respondents	1	4	2			7
		Percentage of responses	14.3	57.1	28.6			100.0

[see Appendix C]

Although all the teachers agreed that mathematics and geometry vocabulary had to be taught, as discovered from the answers to research question 2, the teachers did not have the same opinion regarding the emphasis of the teaching of geometry vocabulary. One teacher, making up 14.3% strongly agreed that teachers emphasised the teaching of geometry vocabulary. Four teachers, representing 57.1% agreed while two teachers representing 28.6% were neutral in their responses to the construct. Although five out of seven teachers maintained that they emphasised geometry vocabulary, this could not be confirmed by the learners, as over 75% of the learners did not agree to the construct.

Two of the interview questions posed to the teachers were asked to indirectly find out from the teachers whether they taught mathematics and geometry vocabularies. The questions and the responses of the seven teachers to each of the questions are reported below.

***What level of attention and focus do you give to the teaching of mathematics vocabulary during your lesson*?**

Two teachers mentioned that they stressed or emphasised vocabulary, as it helped learners understand mathematics concepts better as indicated below.

"I love to stress on that as much as possible because that is what makes the learners understand better. It makes them pick up the language of maths and also helps them understand it better especially when you blend that with ordinary English," (T3Q6).

"Maths is a science subject and so you must get the meaning by using the words. So, if you are teaching it in isolation, you should know when to use the vocabulary else they cannot get the concept well. So, I normally emphasise on that and sometimes too I use it in an oral mental drill, asking them to explain for instance what is a prime number, natural number, whole number and aid them to know all the stuff. I think it helps," (T5Q6).

The two teachers above were emphatic that they taught and emphasised mathematics vocabulary to assist learners to know the meaning of the mathematics words, understand concepts better and pick-up mathematics language. However, the rest of the teachers were evasive in their response to the question, and they digressed as they were not specific as to whether they paid attention to the teaching of mathematics vocabulary. Some of the responses are reported below.

"*You don't have to give them a lot of vocabularies at a go so when you have you have 15mins of vocabulary is enough to help some of the children understand," (T1Q6).*

"In primary six, we teach the lines like perpendicular lines and angles. We also introduce them to polygons. But with the polygons, we teach the names and so on, so they know up to the tenth figure. They also get to know the construction of angles in the third term," (T7Q6).

"One thing is that if they don't understand the concept very well, and the concept goes with the vocabs around it. Every subject has its own vocabulary. In mathematics even though we derive the vocabs from English, we should understand the concept so that when the question is asked, they will analyse the question. And when they can analyse the question very well, that is when they will be able to solve and appreciate the subject. Certain terms must be understood before the child could learn and then answer questions very well," (T2Q6).

The responses above clearly indicate that the teachers do not devote time to teaching mathematics vocabulary. They could not attest to the teaching of mathematics vocabulary, meaning that it was not part of their daily mathematics teaching routine. They did not provide answers to the particular question asked about whether they paid attention to the teaching of mathematics vocabulary, rather, they digressed and gave ambiguous answers avoiding providing a direct answer to the question of mathematics vocabulary teaching, which would have thrown more light on the actual practice in the classroom. The last teacher, in particular, explained that teaching mathematics vocabulary would assist learners to understand concepts better, analyse and solve questions and appreciate the subject but did not ascertain the teaching of mathematics vocabulary much more paying attention to it.

How much of mathematics vocabulary do you teach alongside the teaching of mathematics concepts?

In response to the above question, one teacher admitted that he had not done much regarding the teaching of mathematics vocabulary as reported below.

"I haven't done so much but I try as much as possible to do it when I realise it's needed in the topic. Without it, the learners will find it difficult to understand the topic," (T4Q7).

The above teacher maintains that without the teaching of mathematics vocabulary, learners will find it difficult to understand mathematics topics. However, in practice, the teacher has not put in much effort into the teaching of mathematics vocabulary. Some other teachers explained that they taught mathematics vocabulary as and when they saw it fit, meaning that there was no fixed schedule for the teaching of mathematics vocabulary during the mathematics lesson. This is deduced from some of the teachers' responses below.

"It comes in when I'm teaching so I cannot quantify it. It comes in when and where it is necessary for you to use," (T5Q7)

"I do that sometimes," (T3Q7).

"I cannot really specify them because we have a lot of vocabs that we always give out. Even before we start with the teaching itself, we go around randomly to ask questions and demand answers dealing with mathematics vocabs," (T2Q7).

The teachers could not be specific as to when they taught mathematics vocabulary. Some teachers explained that the teaching of mathematics vocabulary depended on what they were teaching as reported below.

"It depends on what I'm teaching and as and when I have to explain a particular word to the class, then I do that," (T6Q7).

"That is also dependent on the topic being taught, but on the whole, every topic has its own vocabulary. So, as we teach, we chip in some few vocabularies, but in order not for the lesson to be boring, we don't bore them with a lot of vocabularies at a go. We take them one at a time," (T1Q7).

The teachers' responses reveal that there is no planned structure regarding the teaching of mathematics and geometry vocabulary. As indicated above, some of the teachers explained that they taught it sometimes - as and when - depending on what they were teaching. As found by many researchers (Powell, Driver, Roberts & Fall, 2017; Powell & Nelson, 2017; Riccomini et al., 2015), it is not surprising that many learners struggle with mathematics vocabulary as educators ignore mathematics vocabulary when teaching mathematics. Many of the teachers were evasive in their responses to the question and they digressed. This, the researcher believes, is due to a lack of a precise answer to the question. Chipping in mathematics vocabulary during mathematics lessons is insufficient for learners to adequately acquire the language of mathematics, especially geometry. Chiphambo and Feza (2020) explain that geometry has its own vocabulary and both teachers and learners should necessarily know the basic concepts well to comprehend complex concepts and that failure to acquire correct geometry vocabulary impedes learners' learning of geometry. In my opinion, learners need sustained and consistent exposure to mathematics vocabulary to understand mathematics, and, thus, become fluent in explaining their understanding of mathematical concepts and their applications. For example, in a mathematics test, given the picture of a bedroom with a bed and a study table, primary six learners were asked to find and record the dimensions of the bedroom, the table and the bed. Next, they were asked to calculate the area of the bedroom, the area of the bed in the room, and the area occupied by the study table. Finally, the question required the learners to express in the simplest form, the area of the bed as a ratio of the area of the bedroom. The learner must know the meaning of the mathematics vocabularies before they can attempt this question.

Firstly, the learner must have a clear understanding of the meaning of dimension, and how dimensions are measured. Next, they must know the meaning of the area and how to calculate the area of a rectangle. Finally, learners need to know the meaning of ratio. Such an in-depth understanding and application of concepts cannot be acquired through irregular exposure to mathematics vocabulary. Even if the learner knows how to multiply to find the area of the bedroom and the area of the bed, without knowing the meaning of dimension, the learner will not be able to start the process of solving the problem. The understanding of these vocabularies, and their correct use and application, will not be acquired by learners through sporadic exposure to geometry vocabulary.

5.3.2 Conclusion to research question 3

The teachers were inconsistent in their responses regarding laying emphasis on the teaching of geometry vocabulary. The comparison of the teachers' responses to the closed-ended construct, and the interview, serves as evidence. While five teachers, totalling 71.4% agreed and strongly agreed that they laid emphasis on the teaching of geometry vocabulary, the analysis of the interview responses indicated that there was no established structure or routine for the teaching of geometry vocabulary during geometry lessons.

Some of the teachers explained that they did not emphasise geometry vocabulary teaching while some claimed to have done so sometimes, or as and when. This clearly indicates some inconsistency in practice. There is no assigned time in the curriculum, or during instruction, for mathematics/geometry vocabulary teaching and there is also no assigned list of geometry vocabulary to be taught by teachers.

This is further confirmed as the findings reveal that most of the learners do not concur that their teachers teach them geometry vocabulary.

It can be concluded that teachers do not teach geometry and mathematics vocabulary adequately to impact learners' understanding and performance, although they all agree in principle that it is important to teach it.

This agrees with Wanjiru and O-Connor (2015) who maintain that mathematics teachers often neglect the teaching of meaningful mathematics vocabulary. Miller (1993) explained that learners were likely to have difficulty learning mathematics if they did not understand the vocabulary used in mathematics classrooms, textbooks and assessment tests. As explained in the example above, a learner who does not know the meaning of dimension cannot attempt the question at all, not even the first step. To pass that mathematics test, learners need to know the meaning of dimension, area, ratio and simplest form.

Even if a learner understands the process of multiplication, which is required to calculate area and the process of the division involved in expressing in simplest forms, but does not know the meaning of dimension, it will be impossible for the learner to attempt the question. That learner stands the chance of scoring no marks at all in the test, due to lack of understanding of geometry vocabulary, despite his/her knowledge of other mathematical skills required to solve the problem. The lack of teaching and understanding of geometry vocabulary partially accounts for the poor performance of learners in geometry.

5.4 RESEARCH QUESTION 4

5.4.1 How does the teaching of geometry vocabulary influence learners' performance in geometry?

To answer research question 4, firstly, learners and teachers were asked closed-ended questions regarding the influence of geometry vocabulary teaching on learners' performance in geometry. This was followed by an oral interview of selected learners and teachers, and finally, by testing the null hypothesis of this research, which states that "There is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry".

The summary of the responses of learners and teachers to the questionnaire is reported below.

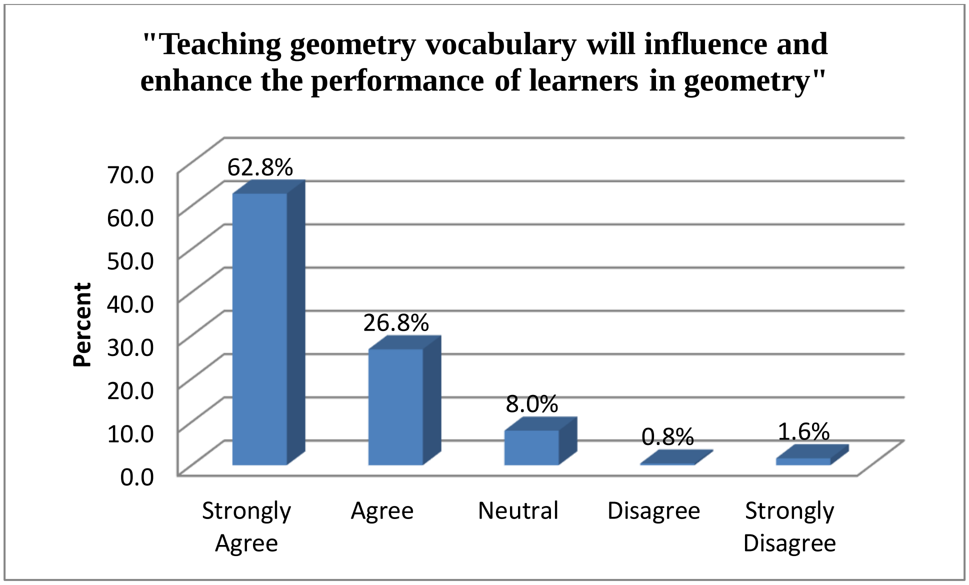


Figure 5.5 **Bar chart showing learners responses to the teaching of geometry vocabulary**

In figure 5.5, 62.8% and 26.8% of the learners strongly agreed and agreed respectively, that the teaching of geometry vocabulary would influence learners' performance positively indicating that 89.6% of the learners believed that the teaching of geometry vocabulary would have a positive influence on learners' geometry performance.

However, 8% were neutral, while 0.4% and an insignificant 1.6% disagreed and strongly disagreed respectively. Since approximately 90% of the learners support the construct, this can be accepted as the general perception of the learners.

The summary of the responses of the teachers to the questionnaire is reported below.

Table 5.16 Summary of teachers' responses to questions 16 & 17

QN	Question	Response	SA	A	N	D	SD	Total
16	Mathematics vocabulary teaching will enhance and impact learners' performance in mathematics.	Respondents	7					7
		Percentage of responses	100					100.0
17	Teaching geometry vocabulary will influence and enhance the performance of learners in geometry.	Respondents	5	2				7
		Percentage of responses	71.4	28.6				100.0

[see Appendix C]

In table 5.16, the results show that all seven teachers support the construct that the teaching of mathematics and geometry vocabulary will influence and enhance learners' performance in mathematics and geometry. Teachers and learners positively agreed that the teaching of mathematics and geometry vocabulary would enhance learners' performance in mathematics in general and geometry in particular.

When the respondents were asked what role they thought teaching mathematics vocabulary would play in the understanding of mathematics concepts, another theme emerged.

5.4.2 Theme 3: The role of mathematics and geometry vocabulary teaching in enhancing learners' performance in geometry

The responses of teachers and learners regarding the role the teaching of mathematics and geometry vocabulary would play in the understanding of mathematics concepts in general, and geometry in particular, are captured below;

"I think when learners understand the mathematics vocabulary, it will help them in understanding the concepts better," (LS8Q5).

"It will play a positive role by helping them to understand the concept of geometry better by giving them more knowledge of the words, examples, angles, lines, etc.," (L3Q6).

"It will play a very important role. The teaching of maths vocabulary in school will help learners understand the concept of mathematics," (L11Q6).

The three learners above explained that the teaching of mathematics and geometry vocabulary would help learners understand mathematics and geometry concepts better.

The responses of two teachers below indicate that the teachers believe that alongside understanding the concept of mathematics, the teaching of geometry and mathematics vocabulary will empower learners to apply mathematical concepts correctly as reported below.

"I believe that in every area of life, reading plays an important role so, with geometry, it is very important for the children to understand the vocabulary before they can apply it," (T1Q5)

"I think like any other topic or most of the topics in mathematics, it is a lifelong lesson that one must learn, therefore I believe that children should be taught very well to understand it so they can apply," (T3Q5).

The teaching of mathematics vocabulary will not only help learners perform better but will, in addition, broaden their understanding of mathematics. This is supported by the response of the learner below.

"It will play an important role in helping us to perform better and broaden our understanding of maths," (L14Q6).

It can be deduced from the quotes above that learners and teachers agreed regarding the teaching of mathematics vocabulary, believing that the teaching of mathematics and geometry vocabulary could enhance learners' understanding of mathematics concepts in general, and geometry in particular. They confirm that learners' ability to apply mathematics concepts to real-life is greatly enhanced by the teaching of mathematics and geometry vocabulary, such as dimensions, circle, distance, diameter, angle, arc length and circumference, to mention a few.

During the oral interview, when the learners were asked what they considered to be the influence of geometry vocabulary teaching on their performance in geometry, the goal of the question was to find out from the respondents if there were any changes in their performance in geometry, based on the geometry vocabulary teaching carried out by the researcher. Some of the learners' responses were as follows:

"It helps us to understand better. In the first test we had, I didn't pass well because we hadn't been taught but when the researcher taught us, I did better in the second test," (L2Q7).

"It will help me to do better in geometry because, I had some problems in geometry and when you came to teach, I could understand better and be able to write the test," (L4Q7).

"The first test in geometry was a bit challenging but since we were taught geometry vocabulary by the researcher, it has been a bit easier for me," (L9Q7).

The three learners above established that the intervention had a positive impact on their performance and that they performed better in the post-test than the pre-test as a result of the vocabulary teaching.

Some other learners maintained that the teaching of the geometry vocabulary helped them understand geometry better and, in turn, resulted in improved performance. This is captured in the responses below:

"My performance will go very high because I have been taught the vocabulary and since I need to apply the terms in mathematics, it will be helpful," (L10Q8).

"The teaching is to help me know and understand the vocabulary and my performance is evidence of what I have been taught. It has increased my performance since I have been taught geometry vocabulary by the researcher," (L10Q7).

"It influences me positively by increasing my performance," (L14Q7).

"It plays a very big role. It can help us excel in geometry and general mathematics," (L11Q8).

"It influences my studying in maths and increases my performance in mathematics," (L14Q8).

The learners generally agreed that geometry and mathematics vocabulary would enhance learners' performance in mathematics.

As reported below, a learner who already performs well in mathematics went on to say that:

"I already do well in maths, but I think if I learn the vocabulary, I will understand better and will help me to do better in mathematics," (L9Q8).

In addition to the above, the other learners attested that mathematics vocabulary teaching would help learners who ordinarily did not like mathematics to love the subject and increase their performance and that without the teaching of the geometry vocabulary, learners wouldn't really perform well in geometry. These views were deduced from the responses below:

"I think it is essential because people do not fancy mathematics. And I feel when they understand these things, it will make them love maths and increase their performance," (L14Q6).

"It improves your understanding of geometry and then your performance will improve," (L15Q7).

"I think without it, you can't really do well, and the learners will perform poorly," (T4Q11).

The findings reveal that the teaching of geometry and mathematics vocabulary will impact positively on learners' performance. As seen above, a learner explained that without geometry and mathematics vocabulary teaching, learners would perform poorly. Learners and teachers affirmed that the teaching of geometry and mathematics vocabulary influenced and enhanced the performance of learners in geometry and mathematics as a subject.

5.4.3 Test of Hypothesis

The null hypothesis and hypothesis of this study were stated as follows:

Null Hypotheses (H_0): There is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

Hypotheses (H_1): There is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry.

The null hypothesis (H_0) of this research was tested, which stated: "There is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry." The study adopted a one-group pre-test/post-test approach. The analysis of the pre-test and post-test scores of all the learners from the three schools revealed that the learners performed poorly in the pre-test with a mean score of 9 out of 25 points, and a standard error of 0.2828 (see Table 5.17 below). The poor performance could be due to a lack of understanding of geometry vocabulary since most of the items on the test required an understanding of geometry vocabulary. The average performance improved to approximately 17 out of 25 points in the post-test, which was administered to the learners a week after the intervention. The intervention involved the teaching of geometry vocabulary to all the learners using various methods. The change in performance from a mean score of 36% in the pre-test to a mean score of 68% in the post-test, could be attributed to the intervention; the special tuition on geometry vocabulary provided to the learners after the pre-test, but before the administration of the post-test. Table 5.17 presents a summary of the learners' performance in the test.

Table 5.17: Summary Results of Pre-test and Post-test

Statistics	Mean	N	Std. Deviation	Std. Error Mean
Pre-test	9.0411	220	4.18556	0.28283
Post-test	16.9658	220	5.05588	0.34164

[see Appendix C]

It is worth noting that in table 5.17, the two test scores correlated significantly. The intervention proved positive as there was a general increase in performance. A Pearson correlation value of 0.551 was estimated with a corresponding p-value of 0.000. The result shows a significant positive relationship, implying that if learners are taught geometry vocabulary, they will generally perform better, and vice versa. This finding is in agreement with Umamaheswari (2020) who posit that mathematics vocabulary instruction assists learners to comprehend and understand mathematics concepts better.

Table 5.18: Correlation between Pre-test and Post-test scores

		Pre-test	Post-test
Pre-test	Pearson Correlation	1	0.551**
	Sig. (2-tailed)		0.000
	N	220	220
Post-test	Pearson Correlation	0.551**	1
	Sig. (2-tailed)	0.000	
	N	220	220
**. Correlation is significant at the 0.01 level (2-tailed).			

[see Appendix R]

In addition, paired learners t-test was conducted based on the null hypothesis that there is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry against the alternative hypothesis that there is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry. Table 5.19 below shows the summary of the results from the paired samples test.

Table 5.19: Results from Paired Samples Test

	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-test / Post-test	- 7.92466	4.4441	0.3003	-8.51653	-7.33279	-26.389	218	0

[see Appendix R]

In table 5.19, the test showed a significant difference in mean scores between the pre-test and post-test scores. The results from table 5.19 above showed an absolute mean difference of 7.92466, with a standard error of 0.3003. The test concluded that the intervention administered was effective with an absolute t-value of 26.389 with 218 degrees of freedom. Hence, the null hypothesis that there is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry was rejected. This implies that there is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry. The results are in tandem with research by De Villiers (2004) who explained that optimal scores in geometry, and an excellent understanding of geometry, is not possible without the clear understanding of the technical terminology of geometry which are geometry vocabularies.

5.4.4 Conclusion to research question 4

Teachers and learners' responses to the closed-ended questions, and the oral interview, confirm that geometry and mathematics vocabulary teaching influences learners' performance, and so does the test of the hypothesis. A learner mentioned that the first test (pre-test) was challenging, but after the researcher taught geometry vocabulary, the next test (post-test) became easier, giving credence to the intervention. The average score of learners improved from 36% to 68% in the pre-test and post-test, respectively. This implies that the findings from the qualitative data confirm those from the quantitative, and the test of the hypothesis. This result confirms what Gharet (2007) established, that incorporating mathematics vocabulary into the mathematics curriculum increased learners' comprehension of mathematical concepts as well as their test scores.

5.5 FURTHER FINDINGS - SCHOOL CASE ANALYSIS

The researcher carried out a comparison of pre-test and post-test scores for each school to see whether the intervention was effective across the three schools. This was necessary since the researcher used a one-group pre-test/post-test approach. The findings are presented below.

5.5.1 School A

Table 5.20: Summary of the comparison of pre-test and post-test scores for School A

School A	**Pretest**	**Post Test**
N	52	52
Mean	6.8173	15.5769
Std. Deviation	3.87049	5.92716
Minimum score	1.00	4.00
Maximum score	21.00	23.00

[*see Appendix R*]

Fifty-two learners took the pre-test and post-test of basic geometry in school A. The pre-test mean score of School A learners was approximately 6.82, while the post-test mean score of the learners was 15.58, which is more than double the mean score of the pre-test. This shows that the intervention influenced the performance of School A learners. In general, the learners in School A improved by over 100%.

5.5.2 School B

Table 5.21 Summary of the comparison of pre-test and post-test scores for School B

School B	Pre test	Post test
N	89	89
Mean	8.5618	17.7697
Std. Deviation	3.81446	4.78163
Minimum score	1.00	4.00
Maximum score	17.00	25.00

[see Appendix R]

In table 5.21, a total of 89 learners participated in the pre-test and post-test of basic geometry in School B. The pre-test mean score of School B learners was approximately 8.56, while the post-test mean score of the learners was 17.77, which is more than double the mean score of the pre-test. There was over 100% improvement in the learners' performance, implying that the intervention influenced the performance of the learners of School B. Worth noting, there was a remarkable difference between the maximum score in the pre-test and post-test which improved from 17 out of 25, to 25 out of 25, indicating that the best learner scored a 100% in the post-test, which did not happen in the pre-test.

5.5.3 School C

Table 5.22: Summary of the comparison of pre-test and post-test scores for School C

School C	Pre test	Post test
N	79	79
Mean	11.0705	16.9241
Std. Deviation	3.90780	4.56652
Minimum	4.00	6.00
Maximum	21.00	24.00

[see Appendix R]

In table 5.22, 79 learners took the pre-test and post-test of basic geometry in School C. The pre-test mean score of School C learners was approximately 11.07, while the post-test mean score of the learners was 16.92, which gives a mean difference of 5.85.

There was a remarkable improvement in the performance of the learners, implying that the intervention influenced the performance of the learners of School C. In conclusion, the learners in all three schools performed better in the post-test than in the pre-test. It is important to note that the differences in the mean scores of the three schools were greatly reduced after the intervention. The mean pre-test scores of the three schools were 6.82, 8.56 and 11.07 respectively, showing some remarkable differences. However, the mean scores for the post-test were 15.58, 17.77 and 16.92 respectively. The intervention closed the gap and reduced the differences between the means. This shows that the vocabulary instruction across all three schools influenced the learners' performance. Although the experiment did not have a control group because the researcher used a one-group pre-test/post-test approach, the school case analysis established that the intervention was the most likely factor that accounted for the remarkable difference in the pre-test and post-test scores in all the three schools. The intervention also accounts for closing the gap between the pre-test and post-test means across the three schools. The teaching of geometry vocabulary influenced learners' performance, raising learners' performance by over 95% overall.

5.6 CHAPTER SUMMARY

Chapter 5 presented and discussed the results of this study considering the four research questions. This study found that geometry vocabularies were not taught in the selected schools. In addition, the study revealed the three main strategies used in the teaching of geometry in primary six in the selected schools in the Greater Accra Region of Ghana, namely drawing diagrams of 2-D shapes and 3-D objects on the board for learners to see, showing pictures of 2-D shapes and 3-D objects to learners, and handling of solid objects by learners. The findings show that these strategies are most commonly used in the order in which they have been listed, with drawing diagrams of 2-D shapes and 3-D objects on the board for learners to see being the most popular strategy used by the teachers and confirmed by the learners. This finding confirms the study of Khairulanuar, Nazre, Sairabanu and Norasikin (2010) on the effects of training method and gender on learning 2D/3D geometry. The results of the study indicated that there was substantial improvement and higher gains of geometrical understanding achieved after students interacted with shapes and objects. Handling of 3-D solids by learners was reported to be an extremely useful learning experience in the geometry learning curve of learners since the activity is hands-on and makes geometry appreciable and readily applicable to real life. The use of this strategy enables learners to realise the usefulness of mathematics and its meaningful application to daily living.

An intriguing fact about one of the findings of this study is the disparity between the claim of teachers and learners regarding videos of geometrical shapes being shown to learners as a geometry teaching strategy. Six out of seven teachers purported that they showed the learners videos of geometrical shapes as a strategy for teaching geometry, while one teacher was unsure about the practice. In contrast, over 90% of the learners did not agree to the claim of the teachers. This paints a picture of uncertainty about the actual practice in the classroom regarding the use of this strategy. The study, therefore, concludes that teachers generally believe that showing learners videos of geometrical shapes is a teaching strategy worth implementing; however, learners are not shown videos of geometrical shapes and objects. Some of the possible reasons why this strategy was not used in the teaching of geometry could be due to lack of resources and time constraints to carry it out, but the teachers clutched at straws.

The study also found that teachers and learners agreed regarding the teaching of geometry and mathematics vocabulary, as both parties concurred that the teaching of geometry and mathematics vocabulary would enhance learners' performance in geometry and mathematics. The improvement in learners' test scores in the post test is an evidence of the positive influence of geometry vocabulary teaching on learners' performance. This finding confirms Brethouwer (2008), maintaining that learners who struggle with retention of mathematical knowledge have inadequate language skills and that learners who have a sound knowledge of vocabulary and are engaged in the specific use of content language, perform more successfully. He indicated that learners believed the use of specific mathematical language helped them be more successful, and they made moderate progress in their performance on assessments.

Despite this unanimous opinion of teachers and learners regarding the teaching of mathematics and geometry vocabulary, the results, however, revealed that although the teachers attested to teaching mathematics vocabulary, the learners were not in agreement; implying that geometry and mathematics vocabulary was not taught routinely during geometry or mathematics lessons. Some teachers divulged that they taught mathematics vocabulary as and when they deemed it fit. The practice of mathematics and geometry vocabulary teaching could, therefore, be regarded as unplanned, unsystematic, arbitrary and irregular in the mathematics classroom. In addition, the teaching programme does not provide a list of geometry vocabularies which learners are expected to learn, making it difficult for teachers to teach geometry vocabulary. This result is consistent with Kranda (2008), who discovered that learners were resistant to change; they preferred to do what came naturally to them. Since the teachers themselves were not previously taught to use precise mathematics vocabulary in their communication about mathematics when they were learners, they had great difficulty teaching it. Furthermore, Miller (1993) recommended that to empower learners with essential mathematical knowledge, teachers must rigorously involve learners in the expressive aspects of mathematics by having them speak and write about mathematics using mathematics vocabulary in the classroom.

Finally, the results of this study revealed that there was a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry. The difference in the performance of the learners in the pre-test and post-test of basic geometry is a strong indication that the improved performance in the post-test can be attributed to the intervention. The intervention involved the teaching of selected geometry vocabulary using various methods of vocabulary instruction, ranging from word search to direct vocabulary instruction, word meaning and picture strategy, and the use of the geometry vocabulary activity sheet developed by the researcher. The mean score of the learners improved from 9 out of 25 points in the pre-test, to 17 out of 25 points in the post-test. The researcher followed up with a simple paired test. The test showed a significant difference in mean scores between the pre-test and post-test scores, an absolute mean difference of 7.92466, with a standard error of 0.3003. The test concluded that the intervention administered was effective with an absolute t-value of 26.389 with 218 degrees of freedom. Hence, the null hypothesis that there is no significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry was rejected, confirming that there is a significant relationship between the teaching of geometry vocabulary and primary six learners' performance in geometry. These results support the findings of research by Gifford and Gore (2008), which showed that underperforming math learners who received vocabulary instruction showed standardised test gains.

CHAPTER 6: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.0 INTRODUCTION

This chapter presents a summary of the findings of this study, which investigated the influence of mathematics vocabulary teaching on year six primary school learners' geometry performance. The main findings of the study are summarised under the four main research questions. Suggestions for further research evolved as a result of lingering questions encountered in the process of conducting this research. This chapter then proffers recommendations of which one is a curricular reform and discusses the limitations of the study, a summary of the study and a summary of the key findings. The chapter ends with concluding remarks.

6.1 SUMMARY OF MAIN FINDINGS

The main findings are presented under the four main research questions.

6.1.1 What are the strategies used in the teaching of geometry in primary six in Ghanaian schools?

One of the main focuses of this study was to find out the strategies used by the class six teachers in the teaching of geometry. The study established the following, which is outlined in 6.1.2 to 6.1.6.

6.1.2 Drawing diagrams of 2-D shapes and 3-D objects on the board

The study found that the most commonly used strategy in the teaching of geometry among the class six teachers in the selected schools was drawing diagrams of 2-D shapes and 3-D objects on the board (see Figure 5.1 and Table 5.5). All seven teachers and 85.2% of the learners attested to this. One possible reason why teachers find this strategy very convenient may be because it does not require much preparation on their part and 2-D shapes and 3-D objects are easy to draw. In a case where the teacher could not draw a named shape or object, the teacher would call on learners who knew how to draw to assist. This agrees with research by Aslan-Tutark and Adams (2017) as pre-service teachers were positive on the effectiveness of using visual aids such as drawings for their geometry learning, supporting the drawing of geometrical shapes and figures as a strategy for teaching geometry.

6.1.3 Showing pictures of 2-D shapes and 3-D objects to learners

Evidence from this study reveals that second on the list of commonly used strategies in the teaching of geometry is showing pictures of 2-D shapes and 3-D objects to learners. Seventy-five-point-two percent of the learners and all seven teachers agree that pictures of 2-D shapes and 3-D objects are shown to learners during geometry lessons (see Table 5.1 and Table 5.2). Teachers show learners pictures of various 2-D shapes and 3-D objects during geometry lessons. The pictures of the geometrical shapes and figures that the primary six learners are supposed to learn are usually drawn in the learners' textbooks, and the teachers simply refer to them. This is also another convenient and easy strategy to use, which requires little or no time for preparation. All the teacher needs to do is pinpoint the page where the pictures can be found in the learners' textbook. This finding agrees with the conclusions of Suydam and Higgins (1977), who maintain that the combined use of both manipulative materials and pictorial representations during lessons is highly effective, confirming the use of pictorial representations as a strategy for teaching geometry.

6.1.4 Handling of solid objects by learners

Handling of solid objects by learners during geometry lessons is the third commonly used strategy for teaching geometry as found by this study. Fifty-two-point-eight percent of the learners confirmed that their teachers gave them solid objects to handle during geometry lessons (see Table 5.3 and Table 5.4). Since a little more than half the learners agreed to this practice during geometry lessons, it could be argued that teachers did not use this strategy sufficiently to enable learners to derive maximum benefit from it. Although teachers and learners agreed that teachers brought solid objects to class for learners to visualize, in the researcher's opinion, learners might not have had enough time to engage with the objects to discover their properties and make comparisons. If teachers give learners ample time to study solid objects, such as cones, cuboids, cylinders, prisms, etc. through physical handling, learners will have a better understanding of these objects.

The findings reveal that handling of solid objects and hands-on activities make geometry lessons interesting, and help learners understand the concept of geometry better. This agrees with research by Aslan-Tutak and Adams (2017), Marchis (2012) and Daher and Jaber (2010) who found the use of hands-on activities very beneficial and meaningful in teaching geometry to pre-service teachers. The pre-service teachers were in favour of this strategy in the teaching of geometry as they found it applicable to real life. Pre-service teachers, in particular, found that handling solid objects was interesting as it made the lessons more enjoyable and interactive.

6.1.5 Cutting out plain shapes

The study found that a valuable strategy, such as learners cutting out plain shapes, is not practised during geometry lessons (see Table 5.8 and Table 5.9). Brown, Collins and Duguid (1989) explain that learning through authentic real-life activities can co-produce knowledge along with cognition. This means that learners are being robbed of this vital experience which could greatly impact their understanding of geometry and improve their performance in geometry tests.

Allowing learners to cut out plain shapes such as triangles, kites, hexagons and make solid objects such as cubes, square-based pyramids, prisms or any other solids for that matter, using their nets and subsequently folding the nets of solid objects to make a model of the object will go a long way to help learners comprehend and consolidate the concept of geometry, especially plain shapes and solid objects, including lines and angles. The values of such authentic real-life activities are immeasurable in learners' learning experiences.

6.1.6 Showing videos of geometrical shapes and figures to learners

The study found that the teachers do not show videos of geometrical shapes and figures to learners as a strategy for teaching geometry during geometry lessons in the selected schools (see Table 5.10 and Fig 5.2). Although six out of seven teachers claim to show videos of geometrical shapes and figures to their learners, only 6% of the learners support the teachers' claim regarding this strategy. Six-point-four percent of the learners were neutral, while the remaining 87.6% did not agree with the teachers. The wide disparity between the teachers' claims and the learners' position regarding the use of this strategy calls for concern. It is a clear case of wish and reality. The teachers believe that it is a good practice to show learners videos of geometrical shapes and figures during geometry lessons and they wish they did; however, in reality, they don't, despite its documented usefulness. The results of Sharma (2018)'s study showed that overall, the classes that received consistent exposure to videos and real-life activities during mathematics lessons had greater mathematics achievement than classes that received only some of the special instructional treatments. It was concluded that learners' performance improved when they were taught through the use of instructional videos and real-life activities individually as well as combined.

6.2 WHAT ARE THE TEACHERS' PERCEPTIONS OF GEOMETRY VOCABULARY TEACHING?

The study also aimed at finding the teachers' perception of geometry vocabulary teaching in primary six. The teachers' and learners' perceptions are outlined below.

6.2.1 Perception and importance of geometry vocabulary teaching

The study found that teachers had a positive perception regarding the teaching of mathematics and geometry vocabulary (see Table 5.13 and *TQ5*). However, they did not emphasise its teaching. The study found that the teaching of mathematics and geometry vocabulary was vital because it made the understanding of geometry and mathematics easier, and helped learners perform better in geometry and mathematics tests (see *T2Q5 & T7Q5)*. The learners also believed that the teaching of mathematics and geometry vocabulary would make mathematics easier and enhance learners' understanding and application of mathematics concepts (see Fig 5.3 & *Q4: L3, L11 & L12*). The findings of this study regarding the teachers' and learners' perception on the teaching of geometry vocabulary are in tandem with the findings of Güner and Gülten, (2016); Toptas, (2015) who state that since geometry is a crucial aspect of mathematics, the use of mathematics language in geometry is extremely important and, as a result, the vocabularies should be taught.

6.2.2 Frequency of geometry vocabulary teaching

Evidence from the study revealed that 95.2% of the learners and 100% of teachers agreed with the teaching of mathematics and geometry vocabulary (see Table 5.13 and Fig. 5.3). The study also found that geometry vocabulary ought to be taught frequently and, if possible, daily (see *L1Q4, L2Q4, L3Q4*).

6.3 HOW DO THE PRIMARY SIX TEACHERS IN THE SELECTED GHANAIAN PRIMARY SCHOOLS TEACH GEOMETRY VOCABULARY?

This study sought to find out how geometry vocabularies are taught in primary six in the selected Ghanaian primary schools in Greater Accra region. The outcome is discussed below.

6.3.1 The teaching of geometry vocabulary

The findings of this study revealed that geometry vocabularies were not taught in the primary schools as only 28% of the learners agreed that their teachers taught geometry vocabularies (see Fig.5.4). The teachers used the vocabularies but did not take time to teach learners the meaning of the words. In some cases, the meanings were mentioned during the lesson, but there was no time set aside in the curriculum to teach geometry or mathematics vocabularies. The practice of mathematics and geometry vocabulary teaching was inconsistent and unplanned. Some teachers taught the required vocabularies as and when they deemed it fit, while others did not bother (see *T3Q7, T4Q7*). This finding agrees with Wanjiru and O-Connor (2015) and many other researchers (Powell et al., 2017; Powell & Nelson, 2017; Riccomini et al., 2015) who maintain that mathematics teachers often neglect the teaching of meaningful mathematics vocabulary.

6.4 HOW DOES THE TEACHING OF GEOMETRY VOCABULARY INFLUENCE LEARNERS' PERFORMANCE IN GEOMETRY?

This study sought to discover whether the teaching of geometry vocabulary would influence learners' performance in geometry. The study established the following, which is outlined in 6.4.1 to 6.4.3.

6.4.1 Influence of geometry vocabulary teaching

In this study, the perception of teachers and learners were the same regarding the teaching of mathematics and geometry vocabulary. All the teachers and 89.6% of the learners agreed that geometry vocabulary teaching would influence and enhance learners' performance in geometry (see Table 5.16, Fig.5.5 and *L15Q7*). The study revealed that teaching geometry vocabulary would improve both learners' understanding of geometry and their performance in it. The study also found that teaching mathematics vocabulary would help learners understand the concept of mathematics, and the understanding of geometry vocabularies would assist learners to apply geometry to real life (see *L8Q5*, *L11Q6* and *T1Q5*). The improvement in learners' test scores in the post test is an evidence of the positive influence of geometry vocabulary teaching on learners' performance (see Table 5.17). This finding is in tandem with the finding of Miller (1993) who explained that learners were likely to have difficulty learning mathematics if they did not understand the vocabulary used in mathematics classrooms, textbooks and assessment tests.

6.4.2 Pre-test and post-test results

The mean score of the learners improved from 9 out of 25 (36%) in the pre-test to 17 out of 25 (68%) in the post-test, which was administered after the learners were taught geometry vocabularies during an intervention that took place after the pre-test. This is in line with the findings of Marzano (2004) that teaching academic vocabulary could positively influence standardised test scores by as much as 33%.

6.4.3 School case analysis

Three schools were used for this study. This study recorded evidence of improved geometry test scores in all three schools after learners were taught geometry vocabulary, giving credence to the intervention. Further analyses of the post-test scores showed that of the three schools used for the study, the mean score of the learners from two of the schools - School A and School B - improved by over 100% in the post-test. The post-test scores of School A learners improved by 129%, from a mean score of 6.82 to 15.58 (see Table 5.20) while that of School B learners improved by 105%, from a mean score of 8.57 to 17.77 (see Table 5.21). The post-test scores of School C learners improved by 52.9%, from a mean score of 11.07 to 16.92 (see Table 5.22). These findings confirm the findings of Gharet (2007) that incorporating mathematics vocabulary teaching and learning into the mathematics curriculum increases learners' comprehension of mathematical concepts as well as their test scores. The findings also confirm the results of the research by Gifford and Gore (2008) showing that underperforming mathematics learners who received vocabulary instruction improved their test scores to as high as 93%, supporting the findings of this study.

6.5 RECOMMENDATIONS

This study was conceptualised against the background of learners' poor performance in mathematics and geometry in Ghana. The study investigated the strategies used in the teaching of geometry in primary six, their teachers' perception of geometry vocabulary teaching, how geometry vocabularies are taught in the selected schools and how geometry vocabulary teaching influences learners' performance in geometry. In the light of the findings of this study, and the foregoing discussion, several recommendations to various stakeholders are presented for consideration.

6.5.1 Recommendations to Policy Makers, Curriculum Developers, and Implementers

The findings of this study are relevant to several categories of educators. As a result, the study offers numerous recommendations to the different groups as discussed below.

6.5.2 Curricular Reform

Wortham (2006) defines curriculum as a planned set of course presented to teachers to arrange teaching and learning in certain ways and levels. Curriculum reform which involves changing the content or form of what is taught in school is sometimes employed as a means to promote educational goals, such as improving the performance of learners (McCulloch, 1998).

This study found that mathematics and geometry vocabularies were not taught in the selected primary schools. Despite the documentation in the literature (Shields, Findlan & Portman, 2005; Lee & Herner-Patnode, 2007; Honig, Diamond, Cole & Gutlohn, 2008; Pierce & Fontaine, 2009; Toptas, 2015; Güner & Gülten, 2016; Powell, Driver, Roberts & Fall, 2017) supporting the importance of mathematics and geometry vocabulary teaching in enhancing learners' understanding, proficiency and performance in mathematics, the Ghana mathematics curriculum as discussed in section 2.3 does not mention the teaching of mathematics and geometry vocabulary. However, the supporting documents given to the heads of schools and school administrators, which has sample lesson plans, have a column for keywords in the mathematics lesson plans. On the plan, there is no mention of when the keywords should be taught. In addition, there is no document containing all the keywords for each content area. Teachers have to search out the keywords for the different mathematics topics.

This study recommends that mathematics and geometry vocabulary teaching, in particular, be incorporated into the Ghana mathematics curriculum to highlight and aid its teaching. The learning and use of mathematics vocabulary are indicated in the mathematics programme of study of the National Curriculum in England (DfE, 2013). The curriculum emphasises the learning of mathematics vocabulary in every content area right from year 1 to 6. In the context of year 6 geometry, the curriculum insists that "teaching should also ensure that learners classify shapes with increasingly complex geometric properties and that they learn the vocabulary they need to describe them" (DfE, 2013, p. 30). In addition, the curriculum states that by the end of year 6, learners should read, spell and pronounce mathematical vocabulary correctly. To ensure uniform implementation of mathematics vocabulary teaching, the Department of Education and Employment provides a Mathematical vocabulary book which indicates all the mathematics vocabulary learners are required to learn year by year progressively throughout primary school (DfEE, 2000).

In the light of the above discussion, the researcher recommends that the Ghana mathematics curriculum be reformed to include mathematics and geometry vocabulary teaching, indicating the specific vocabulary that learners are expected to learn from primary 1 to 6 in a handbook for headteachers and teachers to aid consistent and uniform implementation. This will serve as a guide to the teachers regarding which geometry vocabularies the learners need to learn at every stage. The breakdown of the curriculum should specify the number of hours a week for the teaching of geometry vocabulary to aid its implementation. In addition, research should be carried out to determine the effective strategy/

combination of strategies to be employed in the teaching of mathematics vocabulary to achieve the desired result of an appreciable number of learners becoming highly proficient in mathematics.

6.5.3 Pre-service and In-service Training

Some of the literature reviewed highlighted that many teachers had difficulty teaching geometry (see 2.5), and the findings of this study revealed that mathematics teachers did not teach geometry vocabulary (see Table 5.14, 5.15, Fig 5.4) although they agreed in principle that the practice was laudable and had potential to enhance learners' performance in geometry. The teachers struggled with geometry and were possibly not taught geometry vocabularies when they were in school. It is, therefore, understandable if they do not know how to inculcate the teaching of geometry vocabulary into the mathematics lesson. Teachers should learn how to teach geometry, and geometry vocabularies should be included in the curriculum of study for mathematics teachers in training. In addition, regular in-service training should be provided for mathematics teachers in the field so that they can acquire and update their skills for geometry and geometry vocabulary teaching. This training should be carried out by professionals who have had first-hand experience teaching geometry and geometry vocabularies, to give teachers effective practical skills and activities they can carry out in the classroom.

6.5.4 Recommendations to Teachers

Teaching geometry in the 21st century in the developed world has been greatly enhanced using technology, such as interactive Whiteboards, GeoGebra, Cabri Geometry, Geometer Sketchpad etc. However, in a country like Ghana, with a lag in technological advancements, where the majority of the schools have neither access to nor a constant supply of electricity or computers and the required resources to enhance learners' understanding of geometry through the use of technology, it is important to encourage teachers to maximise the use of local, affordable resources such as objects found in the environment to teach geometry. The use of strategies such as cutting out plain shapes and nets of solid objects on paper to teach geometry should be practised and maximised. The use of resources such as empty corn-flakes boxes as examples of cuboids, tins of milk as cylinders, etc. should be greatly encouraged, explored and used extensively to consolidate the learning of geometry to give learners first-hand experiences with geometric shapes and solids while having fun. These objects can be picked up from the environment or learners could be asked to collect these items from home at no cost.

Teachers should inculcate geometry vocabulary teaching into their geometry lesson plans so that its teaching will be neither optional nor haphazard since mathematics vocabulary instruction should be methodically planned, and executed with purpose and precision, as explained by Riccomini et al. (2015).

6.5.5 Recommendations for further research

The study found three strategies commonly used in the teaching of geometry in primary six in the order in which they are used i.e., drawing diagrams of 2-D shapes and 3-D objects on the board for learners to see, showing pictures of 2-D shapes and 3-D objects to learners, and handling of solid objects by learners. However, further research is required to find more of the strategies used in the teaching of geometry, and establish the most effective strategy or combination of strategies.

The study established that the teaching of geometry vocabulary influenced and enhanced learners' performance in geometry. Further research is required to determine the minimum amount of time required to teach geometry vocabulary for it to influence learners' performance.

In the course of the study, the researcher developed a mathematics vocabulary game intended to be used during the intervention for vocabulary instruction, but it was not. Action research is required to determine whether the use of this mathematics vocabulary game is effective in the teaching of mathematics vocabulary.

6.6 LIMITATIONS

This study was conducted in three schools in the Greater Accra Region. The scope of the study could not cover other regions due to time and financial constraints. Though there was strong evidence of learners' improvement after the teaching of geometry vocabulary in all three schools, the findings of the study cannot be generalised to all the regions and all the primary schools in Ghana, but limited only to learners in Accra. However, the findings provide general information for a wider population of mathematics educators, including curriculum developers and implementers. Other limitations to this study include the use of a one-group pre-test/post-test design and researcher as instrument effect.

6.7 SUMMARY OF THE STUDY

6.7.1 Background of the study

The poor performance of Ghanaian learners in mathematics and geometry and the desire to find possible solutions to this problem was the researcher's motivation to carry out this study. The study then formulated research questions to investigate the main components of this study guided by this purpose. The study highlighted the significance of the study and defined the keywords used in the study. All these were discussed in Chapter 1. The chapter ended with a summary that accentuated the overview of the thesis at a glance.

6.7.2 Literature review

This chapter opened by comparing the primary 6 learners in Ghana with their South African counterparts in terms of age and curriculum expectations. The comparison of the components of the primary 6 Ghana Mathematics syllabus with the South African Mathematics syllabus revealed that the contents of study in the primary 6 Ghana Mathematics syllabus were distributed within grades 5, 6 and 7 of the South African Mathematics syllabi. Vocabulary was defined, and relevant and related literature to this study was reviewed in this chapter. Several studies (Thompson & Rubenstein, 2000; Monroe & Orme, 2002; Shields et al., 2005; Lee & Herner-Patnode, 2007; Pierce & Fontaine, 2009) on the importance of mathematics vocabulary teaching were reviewed. Geometry in the Ghanaian primary school mathematics curriculum was discussed and the challenges experienced by learners in the study of geometry were brought to light from literature (Alex & Mammen, 2012; Salifu, Yakubu, Ibrahim & Amidu, 2020; Yi, Flores & Wang, 2020). Studies by Armah, Cofie and Okpoti (2018); Salifu (2018), Sunzuma and Maharaj (2019); and Yi, Flores and Wang (2020) regarding the state of teachers' and pre-service teachers' geometry knowledge were discussed. Strategies used in the teaching of geometry are limited; however, a few were found and reviewed. Next was discussions on studies related to the influence of mathematics vocabulary teaching on learners' performance (Pierce & Fontaine, 2009; Wearden, 2011; Blessman & Myszczak, 2001; Lewellen, 2008; Gharet, 2007). Possible reasons why teachers did not teach geometry vocabularies, and some ineffective and effective strategies of teaching mathematics vocabularies were also reviewed. The chapter ended with a summary.

6.7.3 Theoretical Framework

The two theories that frame this study - the Van Hiele Theory of geometrical thinking, and the Constructivist Theory of learning were discussed. The Van Hiele Model was discussed concerning geometry vocabulary teaching. Next, constructivism was discussed, followed by the connection between mathematics vocabulary teaching and learning in constructivism. Finally, the relationship between these theories and the teaching of geometry and geometry vocabulary was discussed. The chapter ended with a summary.

6.7.4 Methodology

Chapter 4 presented the methodology used in this study. The research employed both qualitative and quantitative approaches that allowed for the collection of data using both qualitative and quantitative instruments, separately and concurrently. The chapter explained the justification for the sample and the sample size and described the sampling procedure. Purposive sampling technique was used to select the schools, and convenience sampling was used to select the teachers and learners who participated in the study. For the test of basic geometry, the researcher adopted an O1–X–O2 design. Finally, random sampling was used to identify the learners who participated in the oral interview. Data were collected from learners and teachers using closed-ended questionnaires.

In addition, a basic geometry test was administered to all the learners to investigate the learners' understanding of geometry. The researcher carried out an intervention involving all the participating learners. The intervention was mainly the teaching of geometry vocabulary. At the end of it, the same items in the geometry test paper were reshuffled to limit practice effect, then administered as a post-test. Finally, the researcher interviewed a selected number of learners and teachers to find out about the strategies used in the teaching of geometry, their perceived impact of the intervention, and their views on geometry vocabulary teaching.

The study population comprised seven teachers and 250 primary six learners from three schools of similar and comparable social status. All the schools are in the Accra metropolis. The chapter then discussed the credibility, triangulation, transferability, dependability, and confirmability of the study. Finally, ethical issues, namely clearance, permission, consent and assent, anonymity and confidentiality were discussed, and the chapter ended with a summary.

6.7.5 Findings and Discussions

Data analysis was discussed in Chapter 5, while Chapter 6 presented the findings of this study. To arrive at these findings, the researcher triangulated results from six different sources of data, namely learners' questionnaire, teachers' questionnaire, oral interview of teachers, oral interview of learners, a pre-test of basic geometry, and a post-test of basic geometry. The chapter then offered vivid and valid discussions based on the findings and ended with a summary.

6.8 SUMMARY OF KEY FINDINGS

This study established that geometry vocabularies were not taught in the selected schools and found that the teaching of geometry vocabularies improved learners' test scores in geometry by over 77%.

The study also found the three commonly used strategies in the teaching of geometry in primary six in the selected schools, namely drawing of 2-D shapes and 3-D objects on the board, showing pictures of solid objects to learners, and handling of solid shapes by learners. Although learners handled solid shapes during geometry lessons, they were not given enough time to study and explore the shapes. This study also found that learners were not given the opportunity to cut out plain shapes and/or nets of solid objects, depriving the learners of the rich hands-on experience of having fun while they learn and explore the properties of geometrical shapes and figures.

The study developed a prototype lesson plan for teaching 3-D objects, a geometry vocabulary activity sheet, a sample assessment paper for prisms and pyramids (see Appendix S, Appendix J and Appendix T) and recommends a curricular reform to inculcate the teaching of geometry vocabulary in the curriculum with a geometry vocabulary list for learners in each year group as a contribution to knowledge in mathematics education.

6.9 CONCLUDING REMARKS

This study has thrown light on some of the strategies used in the teaching of geometry in primary six. The teachers and learners supported geometry vocabulary teaching. Data was collected using six different instruments, and all six sources confirmed that geometry vocabulary teaching influenced learners' performance in geometry.

Geometry vocabularies, however, were not taught during geometry lessons. As long as teachers continue to disregard the need for geometry vocabulary instruction, learners will continue to have geometry difficulty and underperform in it. Considering that geometry is a vital aspect of mathematics, it is crucial to teach it in such a way that learners understand the concept and can apply it to real life. To achieve this, the teaching of geometry vocabulary should be mandatory.

Although this study has uncovered the three most commonly used strategies in the teaching of geometry in primary six and established that geometry vocabulary teaching influenced learners' performance, some new questions emerged in the course of the study. It is the researcher's joy that this research will be a steppingstone to providing answers to these new queries.

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LIST OF APPENDICES

APPENDIX A: TEACHERS' QUESTIONNAIRE

SECTION A

Fill in the spaces and tick where necessary

Date: _____________

Number: _____________

Gender **Male** ☐ **Female** ☐ **Age:** …………………..

How long have you been teaching? ……………………………….

………

SECTION B

Tick the appropriate responses.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1) I know and understand what geometry is.					
2) I show pictures of 2-D shapes and 3-D objects to learners.					
3) I give learners solid objects to handle.					
4) I draw diagrams of 2-D shapes and 3-D objects on the board for learners to see.					

5) I cut out plain shapes on paper, e.g. rectangles, squares, triangles, etc. for learners to visualize.					
6) I ask learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.					
7) I show learners videos of geometrical shapes and figures.					
8) I ask learners to imagine 2-D shapes and 3-D objects during discussions.					
9) I use hands-on activities to teach geometry.					
10) I know and understand the concept of mathematics vocabulary teaching.					
11) I lay emphasis on the teaching of geometry vocabulary.					
12) Mathematics vocabulary should be taught in schools.					
13) Geometry vocabulary should be taught in schools.					
14) Teaching geometry vocabulary will help learners understand mathematics concepts better.					
15) Teaching mathematics vocabulary will help learners understand geometry better.					

16) Mathematics vocabulary teaching will enhance and impact learners' performance in mathematics.					
17) Teaching geometry vocabulary will enhance and influence the performance of learners in geometry.					
18) It is important to teach geometry vocabulary.					

APPENDIX B: LEARNERS' QUESTIONNAIRE

SECTION A

Fill in the spaces and tick where necessary

Date: _______________

Number: ______________

Name of School: ____

Sex: Male ☐ Female ☐

....

SECTION B

Tick the appropriate responses.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1) I know and understand what geometry is.					
2) Our teacher shows the class pictures of 2-D shapes and 3-D objects.					
3) Gives us solid objects to handle.					
4) Draws diagrams of 2-D shapes and 3-D objects on the board for us to see.					
5) Our teacher cuts out plain shapes on paper e.g. squares, rectangles, triangles etc. for us to visualize.					

6) The teacher asks the learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.					
7) We watch videos of geometrical shapes and figures.					
8) My teacher asks us to imagine the shapes and the figures during discussions.					
9) I have been taught geometry vocabulary.					
10) I understood what I was taught in geometry vocabulary.					
11) I remember almost all that I was taught in geometry vocabulary.					
12) I can answer any questions asked on geometry vocabulary.					
13) Mathematics vocabulary should be taught in schools.					
14) Mathematics vocabulary helps me understand mathematics concepts better.					
15) Teaching geometry vocabulary will help learners understand geometry better.					
16) Teaching geometry vocabulary will influence the performance of learners in geometry.					

APPENDIX C: ANALYSIS OF QUESTIONNAIRES

Response of teachers about the teaching of mathematics and geometry vocabulary in school

QN	Construct/Perception		SA	A	N	D	SD	Tol.
1	I know and understand what geometry is	Count	4	3				7
		Percent	57.1	42.9				100
2	I show pictures of 2-D shapes and 3-D objects to learners	Count	4	3				7
		Percent	57.1	42.9				100
3	I give learners solid objects to handle.	Count	4	2	1			7
		Percent	57.1	28.6	14.3			100
4	I draw diagrams of 2-D shapes and 3-D objects on the board for learners to see.	Count	7					7
		Percent	100.0					100
5	I cut out plain shapes on paper, e.g. rectangles, squares, triangles, etc. for learners to visualize.	Count	2	3		1	1	7
		Percent	28.6	42.9		14.3	14.3	100
6	I ask learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.	Count	2	3	2			7
		Percent	28.6	42.9	28.6			100
7	I show learners videos of geometrical shapes and figures.	Count	4	2	1			7
		Percent	57.1	28.6	14.3			100
8	I ask learners to imagine 2-D shapes and 3-D objects during discussions.	Count	1	1	1	3	1	7
		Percent	14.3	14.3	14.3	42.9	14.3	100
9	I use hands-on activities to teach geometry.	Count	4	2	1			7
		Percent	57.1	28.6	14.3			100
10	I know and understand the concept of mathematics vocabulary teaching.	Count	4	3				7
		Percent	57.1	42.9				100
11	I lay emphasis on the teaching of geometry vocabulary.	Count	1	4	2			7
		Percent	14.3	57.1	28.6			100

12	Mathematics vocabulary should be taught in schools.	Count	7					7
		Percent	100.0					100
13	Geometry vocabulary should be taught in schools.	Count	7					7
		Percent	100.0					100
14	Teaching geometry vocabulary will help learners understand mathematics concepts better.	Count	7					7
		Percent	100.0					100
15	Teaching mathematics vocabulary will help learners understand geometry better.	Count	6	1				7
		Percent	85.7	14.3				100
16	Mathematics vocabulary teaching will enhance and impact learners' performance in mathematics.	Count	7					7
		Percent	100.0					100
17	Teaching geometry vocabulary will enhance and influence the performance of learners in geometry.	Count	5	2				7
		Percent	71.4	28.6				100
18	It is important to teach geometry vocabulary.	Count	6	1				7
		Percent	85.7	14.3				100

Response of learners about the teaching of mathematics and geometry vocabulary in school

QN	Construct/Perception		SA	A	N	D	SD	Total
1	I know and understand what geometry is.	Count Percent	39 15.6	82 32.8	66 26.4	49 19.6	14 5.6	250 100.0
2	Our teacher shows the class pictures of 2-D shapes and 3-D objects.	Count Percent	113 45.2	75 30.0	24 9.6	27 10.8	11 4.4	250 100.0
3	Gives us solid objects to handle.	Count Percent	71 28.4	61 24.4	30 12.0	72 28.8	16 6.4	250 100.0
4	Draws diagrams of 2-D shapes and 3-D objects on the board for us to see.	Count Percent	141 56.4	72 28.8	15 6.0	17 6.8	5 2.0	250 100.0
5	Our teacher cuts out plain shapes on paper e.g. squares, rectangles, triangles etc. for us to visualize.	Count Percent	56 22.4	51 20.4	33 13.2	82 32.8	28 11.2	250 100.0
6	The teacher asks the learners to cut out plain shapes on paper e.g. squares, rectangles, triangles etc.	Count Percent	19 7.6	40 16.0	36 14.4	105 42.0	50 20.0	250 100.0
7	We watch videos of geometrical shapes and figures.	Count Percent	6 2.4	9 3.6	16 6.4	107 42.8	112 44.8	250 100.0
8	My teacher asks us to imagine the shapes and figures during discussions.	Count Percent	35 14.0	46 18.4	33 13.2	76 30.4	60 24.0	250 100.0
9	I have been taught geometry vocabulary.	Count Percent	27 10.8	43 17.2	52 20.8	78 31.2	50 20.0	250 100.0
10	I understood what I was taught in geometry vocabulary	Count Percent	25 10.0	40 16.0	48 19.2	89 35.6	48 19.2	250 100.0

11	I remember almost all that I was taught in geometry vocabulary.	Count	17	28	58	91	56	250
		Percent	6.8	11.2	23.2	36.4	22.4	100.0
12	I can answer any questions asked on geometry vocabulary	Count	9	30	78	80	53	250
		Percent	3.6	12.0	31.2	32.0	21.2	100.0
13	Mathematics vocabulary should be taught in schools.	Count	189	49	5	5	2	250
		Percent	75.6	19.6	2.0	2.0	.8	100.0
14	Mathematics vocabulary helps me understand mathematics concepts better.	Count	133	89	18	5	5	250
		Percent	53.2	35.6	7.2	2.0	2.0	100.0
15	Teaching geometry vocabulary will help learners understand geometry better.	Count	158	69	19	1	3	250
		Percent	63.2	27.6	7.6	0.4	1.2	100.0
16	Teaching geometry vocabulary will influence the performance of learners in geometry.	Count	157	67	20	2	4	250
		Percent	62.8	26.8	8.0	0.8	1.6	100.0

APPENDIX D: BASIC GEOMETRY PRE-TEST

Name of School: ……………………………………………………

Date: ……………………… Class: …………………… Number: ……………

BASIC GEOMETRY ACHIEVEMENT TEST ( )

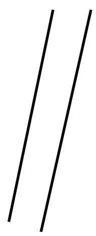
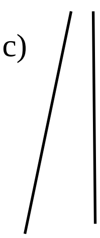
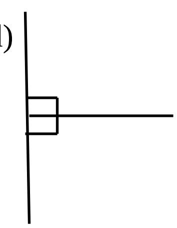
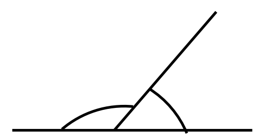
Read each question carefully and answer accordingly.

Circle the correct answer for questions **1** to **10**

1) Two or more lines are said to be parallel when they are equal in length.

   a) True b) False

2) Circle the alphabets for the sets of parallel lines.

   a)  b)  c)  d)  e) 

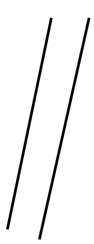
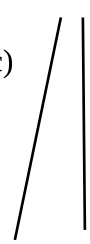
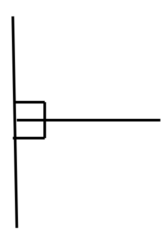
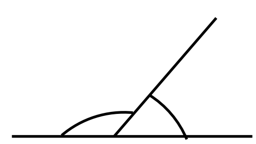
3) Two or more lines are said to be perpendicular when

   a) They meet at a point

   b) They meet at right angles

   c) They meet at a point and are equal

4) Circle the alphabet for the set of perpendicular lines.

   a)  b) c)  d)  e) 

5) An acute angle is

a) Greater than 180^o but less than 360^o. b) Greater than 90^o but less than 180^o. c) Equal to 180^o.
d) Equal to 90^o e) Less than 90^o

6) Which of these is an acute angle?

a) 200^o b) 50^o c) 154^o d) 90^o e) 180^o

7) A reflex angle is

a) Greater than 180^o but less than 360^o.

b) Greater than 90^o but less than 180^o.

c) Equal to 180^o

d) Equal to 90^o

e) Less than 90^o

8) Which of these is a reflex angle?

a) 55^o b) 90^o c) 172^o d) 180^o e) 195^o

9) An obtuse angle is

a) Greater than 180^o but less than 360^o.

b) Greater than 90^o but less than 180^o.

c) Equal to 180^o

d) Equal to 90^o

e) Less than 90^o

10) Which of these is an obtuse angle?

a) 215^o b) 180^o b) 115^o c) 90^o d) 72^o

*<u>Fill in the missing word for questions **11** to **15**</u>*

11) The measure of a straight angle is equal to ______________________

12) The measure of an angle at a point is equal to ____________________

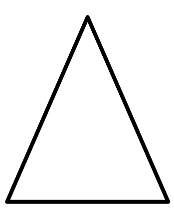
13) The measure of a right angle is equal to _________________________

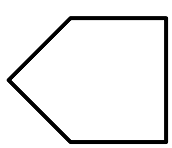
14) James draws a triangle and measures the three angles in the triangle. If he measures the angles correctly, the sum of the three angles should be equal to ________________

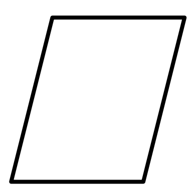
15) Two of the angles of a triangle measures 54° and 67° respectively. What is the measure of the third angle? ______________________________

Show working in the space provided

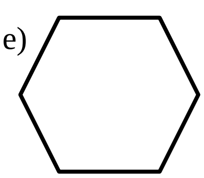
16) Which of these are quadrilaterals? Circle them

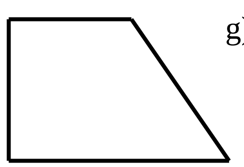
a) 

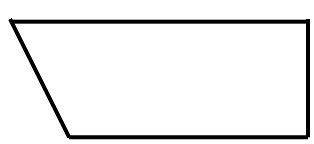
b) 

c) 

d) 

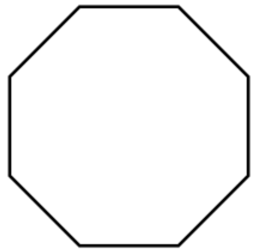
e) 

f) 

g) 

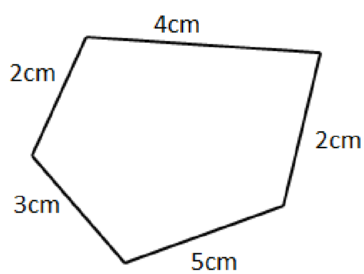
17) A five-sided polygon with all the sides different in length is called a (n) ________________pentagon.

18) Name this shape



Answer: ______________________

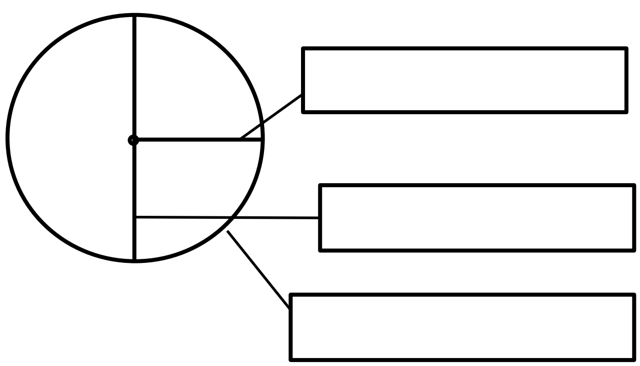
19) Calculate the perimeter of the shape below.



Show working in the space provided

Answer: ______________________________

20) Label the parts of the circle below.



APPENDIX E: BASIC GEOMETRY POST TEST

Name of School:……………………………………………………

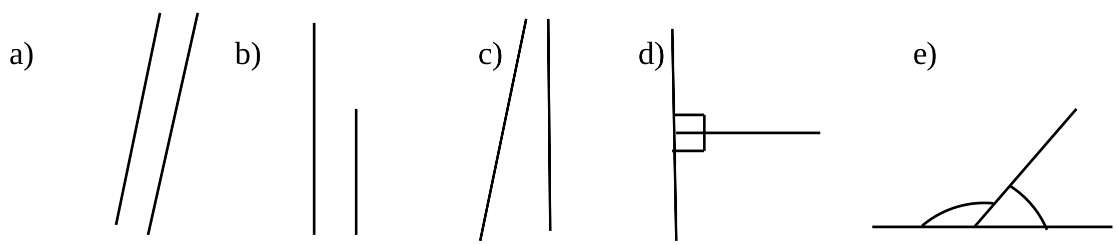
Date:……………………… Class:…………………… Number:……………

<u>BASIC GEOMETRY ACHIEVEMENT TEST (2)</u>

<u>Read each question carefully and answer accordingly.</u>

<u>Circle the correct answer for questions **1** to **10**</u>

1) Circle the alphabets for the sets of parallel lines.



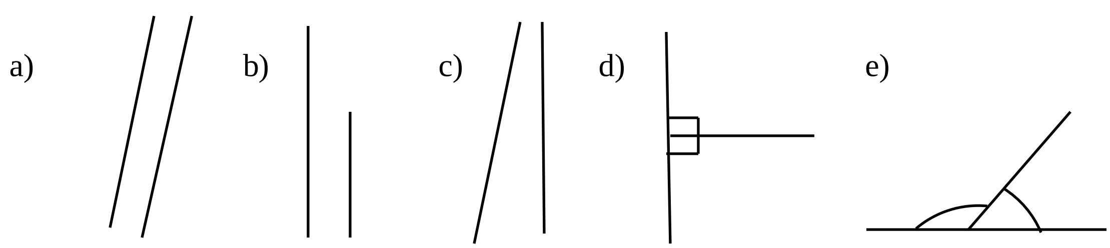
2) Two or more lines are said to be perpendicular when

   a) They meet at a point

   b) They meet at right angles

   c) They meet at a point and are equal

3) Circle the alphabet for the set of perpendicular lines.



4) Two or more lines are said to be parallel when they are equal in length.

a) True b) False

5) Which of these is an acute angle?

a) 200^o b) 50^o c) 154^o d) 90^o e) 180^o

6) An acute angle is

a) Greater than 180^o but less than 360^o b) Greater than 90^o but less than 180^o c) Equal to 180^o.
d) Equal to 90^o e) Less than 90^o

7) A reflex angle is

a) Greater than 180^o but less than 360^o.

b) Greater than 90^o but less than 180^o.

c) Equal to 180^o

d) Equal to 90^o

e) Less than 90^o

8) An obtuse angle is

a) Greater than 180^o but less than 360^o.

b) Greater than 90^o but less than 180^o.

c) Equal to 180^o

d) Equal to 90^o

e) Less than 90^o

9) Which of these is an obtuse angle?

a) 215^o b) 180^o c) 115^o d) 90^o e) 72^o

10) Which of these is a reflex angle?

a) 55^o b) 90^o c) 172^o d) 180^o e) 195^o

Fill in the missing word for questions **11** to **15**

11) James draws a triangle and measures the three angles in the triangle. If he measures the angles correctly, the sum of the three angles should be equal to ________________

12) The measure of a straight angle is equal to ______________________

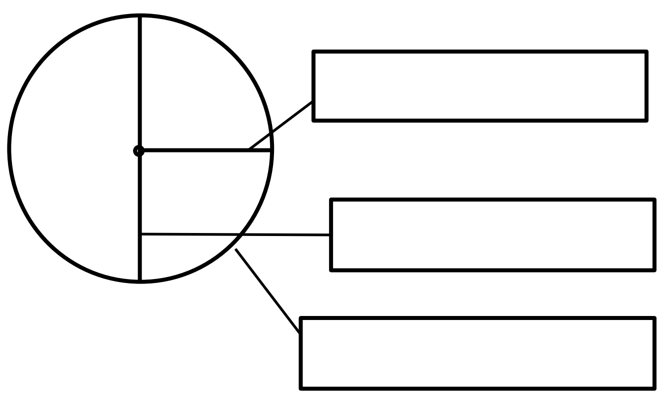
13) The measure of an angle at a point is equal to ____________________

14) Two of the angles of a triangle measures 54^o and 67^o respectively. What is the measure of the third angle? ______________________________

Show working in the space provided

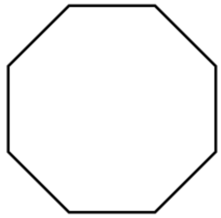
15) The measure of a right angle is equal to _________________________

16) Label the parts of the circle below.



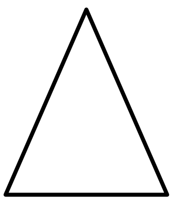
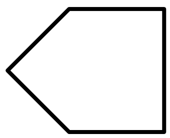
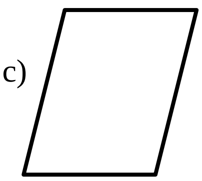
17) A five-sided polygon with all the sides different in length is called a (n) _________________pentagon.

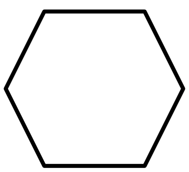
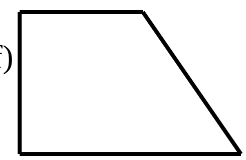
18) Name this shape



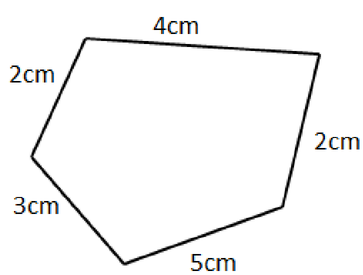
Answer: ______________________

19) Which of these are quadrilaterals? Circle them

a)  b)  c)  d) 

e)  f)  g) 

20) Calculate the perimeter of the shape below.



Show working in the space provided

Answer: ______________________________

APPENDIX F: INTERVIEW GUIDE FOR LEARNERS

Strategies used in teaching geometry

1. What methods were used by your teacher in teaching you geometry?

Whether or not geometry vocabularies are taught

2. What have you been taught in geometry vocabulary?

3. What can you remember about the concepts you were taught in geometry vocabulary?

4. How frequently should mathematics vocabulary be taught in school and why?

Influence of mathematics / geometry vocabulary teaching on learners' performance in geometry

5. What role do you think the teaching of mathematics vocabulary plays in the understanding of mathematics concepts by learners?

6. What role would the teaching of geometry vocabulary play in helping learners understand geometry better?

7. What do you consider as the influence of geometry vocabulary teaching on your performance in geometry?

8. What do you consider as the influence of mathematics vocabulary teaching on your performance in mathematics?

APPENDIX G: INTERVIEW GUIDE FOR TEACHERS

Strategies used in teaching geometry

1. What are the relevant methods and strategies you use to teach geometry to primary six learners?
2. How much of hands-on activities do you use to teach geometry?
3. How do you teach geometry? Is it in abstract? Do you draw the geometrical shapes and figures on the board or do you ask learners to imagine them?
4. Do you display and show learners 2-D shapes and 3-D objects during geometry lessons?

Teachers' perception on geometry vocabulary teaching

5. What is your understanding and perception of the concept of geometry vocabulary teaching?

Whether or not geometry vocabularies are taught

6. What is the level of attention and focus you give to mathematics vocabulary teaching during your lessons?
7. How much of mathematics vocabulary do you teach alongside the teaching of mathematics concepts?

Influence of geometry teaching on learners' performance in geometry

8. What level of emphasis or detail do you observe when teaching geometry vocabulary?
9. What do you consider to be the impact of geometry vocabulary teaching on the performance of learners in primary six?
10. What is the impact of mathematics vocabulary teaching on the performance of learners in mathematics as a discipline?

Strategies for teaching Geometry vocabulary

11. Describe and enumerate the methods you use to teach mathematics vocabulary to ensure the understanding of your learners in primary six?

APPENDIX H: LEARNERS' RESPONSES TO INTERVIEW QUESTIONS

QUESTION 1

What methods were used by your teacher in teaching you geometry?

LEARNER NO.	ANSWERS
1	Addition, measuring and drawing
2	Drawing, calculations, measuring and sometimes things around us.
3	He also drew diagrams to show lines and angles on the board. He took us to the maths and science facility to show us lines and angles. He made us point to lines and angles in the classroom.
4	He used our classroom, the length of our classroom, the lines and angles of our classroom and also, he uses some of the learners to teach us the subtractions and heights.
5	My teacher draws the shapes on the board and writes the numbers of the perimeter and area then we are asked to find the perimeter and the area. After that we do angles of shapes and we learn about lines and angles.
6	Sometimes, he gets the methods on the board. He cuts out some shapes then he uses the cards which are like shapes; the squares, rectangles etc. he sometimes draws the images and the figures on the board and teaches us what we need to do.
7	He sometimes gives us examples or draws them on the board and gives us their meanings. He sometimes draws them and label the parts as well.

8	Our teacher brought in wooden 3-D shapes to demonstrate and show us lines and angles. He also drew diagrams that were showing lines, and angles on the board. He took us to the maths and science facility to show us lines and angles. He made us point to lines and angles in the classroom.
9	He brought us shapes to look at and showed us how many lines, edges, and vertices they had. He also taught us types of triangles. He brought pictures of solids such as cubes and cuboids to show us how vertices they had for us to understand.
. 10	Sometimes he brings shapes and shows to us in the class. He shows us the edges, the vertices and faces and tests us later. He gives notes also.
. 11	He shows us vertices, angles and types of lines as well as triangles. He showed us the characteristics of the angles and shapes.
. 12	When he’s teaching, he doesn’t cut out shapes but draws the shapes on the board for us to see and he teaches us how to draw them as well. He helps us to when he faces difficulties.
. 13	He sometimes draws the shapes on the board and explains how many lines, vertices and how many angles it has. He sometimes brings items that have specific shapes and explain them to us.
. 14	He sometimes drew them. He shows us shapes, edges, vertices and faces.
. 15	He brought shapes to class and involved us in identifying the angles, edges and faces.

INTERVIEW WITH LEARNERS

QUESTION 2

What have you been taught in geometry vocabulary?

LEARNER NO	ANSWERS
1	Like acute angles and horizontal lines, vertical lines and parallel lines. Horizontal lines are lines that run from east to west and from west to east. Vertical lines run from north to south and from south to north. Parallel lines are not vertical or horizontal lines. They are slanted lines that do not meet.
2	A rectangle is a quadrilateral because it has 4 sides. We have been taught the parts of circles and polygons.
3	I have been taught lines, angles and some areas in perimeter.
4	I have been taught angles, lines and shapes.
5	Not much. We have been taught how to tell names of the shapes.
6	We didn’t know geometry vocabulary, but he used some of the words. He uses parallel lines and angles, squares, shapes, octagon, etc. last time he taught us polygons. From 5-sided figure to 10-sided figure.
7	How to draw a circle and label its parts, e.g. the diameter is a line dividing a circle into 2.

8	Our teacher taught us angles. He taught us two types of angles, which are acute angles and obtuse angles. Acute angles are angles that measure less than 90 degrees. Obtuse angles are angles that that measure more than 90 degrees but less than 180 degrees. He also taught us horizontal lines. They are lines that run from left to right or from east to west and vertical lines are lines that run from north to south or top to down.
9	I have been taught triangles. Isosceles triangles have two of its angles equal. Equilateral triangle has all of its sides and angles equal and each of these angles measure 60 degrees.
. 10	I have been taught solid shapes, triangles, flat shapes.
. 11	We have been taught angles like acute, obtuse, reflex angles and line. With lines he was taught horizontal lines, lines and types of triangles.
. 12	I can remember the angles, triangles and lines.
. 13	I have been taught lines, the different types of line, the angles and their types as well as triangles.
. 14	I have been taught types of lines like parallel lines, perpendicular lines, lines, right angles, triangles, isosceles triangles, scalene triangles etc.
. 15	I was taught how to name lines, the degrees of angles and shapes.

INTERVIEW WITH LEARNERS

QUESTION 3

What can you remember about the concepts you were taught in geometry vocabulary?

LEARNER NO	**ANSWERS**
1.	If she teaches and explains, I just read it one more time and I get it.
2.	I remember horizontal lines move from the west to west and west to the east, vertical line is from south to north and north to south, the obtuse triangle. The obtuse angle which is more than 90 degrees but less than 180 degrees.
3.	I remember number lines and angles. Straight angles measure 180 degrees, right angles measure 90 degrees.
4.	I can remember oblique lines are lines that are slanted. And vertical lines are lines that are from east to west, horizontal lines are lines from north to south. I also remember angles are equal to 90 degrees and straight lines are equal to 180 degrees.
5.	I was taught how to find the area of squares. The length of a shape and its volume. As well as the measure net of an angle.
6.	We were taught how to draw shapes with rulers, pencils and compass. We have maths every day and out teacher uses the geometry vocabulary to teach us.
7.	The parallel lines, the obtuse angles, the acute angles, the reflex angles and perpendicular lines.

8.	I can remember angles. Some examples are acute angles, obtuse angles, and reflex angles. Acute angles are angles that measure less than 90 degrees. Obtuse angles are angles that measure more than 90 degrees but less than 180 degrees. A reflex angle is an angle that measures more than 180 degrees but less than 360 degrees.
9.	For an angle such as perpendicular angles, it is two or more lines that meet at right angle and measures exactly 90 degrees.
10.	I can remember perpendicular lines are lines that meet. Angles is the measure of the turn at which lines meet. I also remember horizontal and vertical lines, oblique lines which are lines that are slanted.
11.	I remember acute angles are that measure below 90 degrees. Obtuse angles measure above 90 degrees but less than 180 degrees.
12.	I remember parallel lines are two or more lines that have equal distance but can never meet.
13.	So far, we have been taught lines, angles, etc.
14.	I remember parallel lines have the same distance but never meet at a point. I remember the types of triangles and parts of a circle like the radius, circumference and the diameter.
15.	If I am taught, I will understand

INTERVIEW WITH LEARNERS

QUESTION 4

How frequently should mathematics vocabulary be taught in school and why?

LEARNER NO	**ANSWERS**
1.	Mathematics vocabulary should be taught every day.
2.	Every day because it gives more understanding about the concepts we learn.
3.	It has to be taught frequently because it helps learners. When the teacher is about to teach the subject, it makes it easier for learners to understand.
4.	It should be taught very often. So that children will know mathematics very fast and it will also be easier for them.
5.	I think it should be taught. And should be taught daily.
6.	There is the teacher to teach it daily and the need to make sure the learners understand it well. Sometimes, you can use the oral way of teaching. For instance, when you want to say 1 + 1, you can write it in words form for the learners to understand better. And it should be taught every day.
7.	Yes. I think maths vocabulary should be taught every day.
8.	I think geometry vocabulary should be taught in schools every day. Else, the learners will not have the benefit of learning mathematics vocabulary faster.

9.	I think it should be taught frequently so that learners will understand the terms in mathematics better.
10.	It should be taught every day. Every day that we have mathematics, there should be the teaching of mathematics vocabulary because it is need in helping the learners understand the teaching better.
11.	Mathematic vocabulary should be taught every day. Because we need to apply them when the need arises.
12.	Every day because I know that when we are taught the geometry vocabularies, it will make the learning of maths easier.
13.	Everyday. Though we have specific period for maths, I think we should have a separate period for geometry only because maths is broad and if separated, it will help a lot.
14.	I think it should be taught everyday even if it is for short periods.
15.	5 times a week

INTERVIEW WITH LEARNERS

QUESTION 5

What role do you think the teaching of mathematics vocabulary plays in the understanding of mathematics concept by learners?

LEARNER NO	**ANSWERS**
1.	If you don’t learn it now, in future you cannot apply it
2.	Yes, because sometimes what we do in class aids us in understanding better.
3.	It helps them. Maybe when you are teaching, it goes straight to the point. It will also play a positive role by helping learners excel in maths.
4.	It will help them in their lives because maths is everywhere. So, any aspect of our lives, maths will help them.
5.	It helps learners in their daily lives. It helps to understand shapes and anything that has to do with shapes, lines and edges.
6.	It will help the learners to understand some of the words in mathematics. It will have a good influence on them. Because a lot of learners do not understand mathematics vocabulary.
7.	It will help learners write their B.E.C.E. (Basic Education Certificate Examination) and also help them in understanding the concepts.

8.	I think when learners understand the mathematics vocabulary, it will help them in understanding the concepts better.
9.	I think it will play a big role in learners understanding. Because it helps them to understand the terms better so that when they are asked questions, they will get a better understanding of the questions.
10.	When you know the vocabulary of what is being taught, it will aid in understanding and answering of questions.
11.	Maths vocabulary will help me to understand maths better.
12.	It helps learners to understand some of the vocabulary they didn’t know before.
13.	It plays a very good role. Example, during lessons, we come across words we do not understand. So, I believe if we are taught the vocabulary, it will help us understand the concepts used in maths.
14.	I think it plays a crucial role. When we get to learn these things, we can apply them when we come across them.
15.	It improves your performance in mathematics.

INTERVIEW WITH LEARNER

QUESTION 6

What role would the teaching of geometry vocabulary play in helping learners to understand geometry better?

LEARNER NO	**ANSWERS**
1.	When they are explained we get a better understanding. You can apply them.
2.	It will help them to use their skills and whatever they have been taught to write or understand anything on the topic.
3.	It will play a positive role by helping them to understand the concept of geometry better by giving them more knowledge of the words like angles, lines, etc.
4.	When they teach them the deeper language of geometry to their understanding, it will help them in answering questions to pass.
5.	It will help them a lot. Because then they need to understand the perimeter or area of a particular shape, they can refer to the vocabulary of geometry they were taught.
6.	When we are taught geometry vocabulary, we understand it better. Most often we draw the shapes and we are asked to identify. So, when the geometry vocabularies are taught, it will help us to mention the names easily.
7.	It will help learners in understanding better. I think they should be taught to learners.

8.	If the teacher teaches geometry vocabulary, it will help the learners be able to understand geometry better. Ones they have gotten the vocabulary and geometry, it will make learning easier.
9.	Geometry vocabulary will help learners have a better understanding the concept of geometry.
10.	The role is to help children gain better understanding. The vocabulary helps learners in the interpretation of mathematics questions. During geometry lessons, the vocabulary will help learners to understand so that they can also explain to others.
11.	It will play a very important role. The teaching of maths vocabulary in school, will help learners understand the concept of mathematics.
12.	It does play a role.
13.	It will play an important role of helping us to perform better and broaden our understanding in maths.
14.	I think it is essential because people do not fancy mathematics. And I feel when they understand these things, it will make them love maths and increase their performance.
15.	It makes you understand geometry better.

INTERVIEW WITH LEARNERS

QUESTION 7

What do you consider as the influence of geometry vocabulary teaching and your performance in geometry?

LEARNER NO	ANSWERS
1.	When they are explained and we get the better understanding, we are able to apply them.
2.	It helps us to understand better. In the first test we had, I didn't pass well because we hadn't been taught but when the researcher taught us, I did better in the second test.
3.	It will play a very good role in my university level. It helps me improve in mathematics.
4.	It will help me to do better in geometry because, I had some problems in geometry and when you came to teach, I could understand better and was able to write the test.
5.	It will help me lot because I haven't been doing well in that subject.
6.	It will really help me because I didn't understand a lot of things in geometry vocabulary like parallel line and how to draw them. But when since we were taught, geometry vocabulary has been easier for me.
7.	It will help me do better in geometry.

8.	When in am able to understand geometric vocabulary well and know the concept, I am able to understand the questions and answer them.
9.	The first test in geometry was a bit challenging but since we were taught geometry vocabulary by the researcher, it has been a bit easier for me.
10.	The teaching is to help me know and understand the vocabulary and my performance is evidence of what I have been taught. It will therefore increase my performance since I have been taught geometry vocabulary by the researcher.
11.	It will help boost our performance in geometry. Because it will help us understand how things work in geometry.
12.	I get to understand the vocabulary in both the geometry and general mathematics. It will also help me do well in maths lessons in school.
13.	When we are taught geometry vocabulary in school, it will make my performance in geometry lessons better because I would know the terms used in geometry and which concept it falls under.
14.	It influences me positively by increasing my performance.
15.	It improves your understanding of geometry and then your performance will improve.

INTERVIEW WITH LEARNERS

QUESTION 8

What do you consider as the influence of mathematics vocabulary teaching on your performance in mathematics?

LEARNER NO	**ANSWERS**
1.	It makes mathematics easier to understand.
2.	Yes. It will help me understand the vocabularies used in the teachings.
3.	It will help me understand geometry angles and geometry as a whole better.
4.	It will help me get a ‘1’ in the B.E.C.E. And help in my S.H.S education as well.
5.	It will help me a lot. Because I got a better understanding after the teaching and the test.
6.	It will help because I need to understand the question to be able to answer questions.
7.	It will help in better understanding of the concepts.
8.	When I am taught mathematics vocabulary, it will help me to understand mathematics better.
9.	I already do well in maths. But I think if I learn the vocabulary, I will understand better and will help me to do better in mathematics.

10.	My performance will go very high because I have been taught the vocabulary and since I need to apply the term in mathematics, it will be very helpful.
11.	It plays a very big role. It can help us excel in geometry and general mathematics.
12.	It doesn’t affect my performance in mathematics.
13.	Some things they teach in geometry sometimes are applicable in maths. So, my performance will also be better in maths.
14.	It helps in studying maths and increases performance in mathematics.
15.	It also improves your mathematics understanding.

APPENDIX I: TEACHERS' RESPONSES TO INTERVIEW QUESTIONS

QUESTION 1.

What are the relevant methods and strategies you use to teach geometry to primary six learners?

TEACHER 1: I see geometry to be a very practical subject in every area of life, so I think there is the need for us to "practicalise'' it in the classroom. We use cut outs, card boards where the learners will also be involved in it and makes the lesson very interesting and easy.

TEACHER 2: What I normally do is that, most of the time I use the real object in teaching most if this geometry. In geometry we have the 2-dimentional and the 3-dimentional shape. With the 3-dimentional, we use the tangible items to each where we show them the vertices, the edges as well. But with the 2-dimentional type of geometry, we can draw some of them either on the board for them to copy or we can also use the manila card where we do some sketches on it for the learners to see and observe them very well. So, this is what we usually do to teach for them to understand very well.

TEACHER 3: I still see them as children and for that matter I like to be as faster as possible. For this reason, for solid shapes for instance, I usually bring solid shapes myself and encourage them to bring some as well. We use them together for the lesson. But when it comes to lines, angles and so on, I use drawings most often and the classroom settings as well to help them understand the concept.

TEACHER 4: For primary 6 learners, geometry can look very abstract to the children at that level and so we try as much as possible to come down to their level. We have to show the diagram to demonstrate. For instance, to demonstrate angles as where two lines meet, your can have two sticks or something to join together and show the space where the angle is formed and that will make it easier.

TEACHER 5. Before they come here, they know something about geometry, but the point is they don't know the name as geometry. They have been doing this since class one, so we build on this to develop them.

TEACHER 6. I use the discussion and practical methods like the shapes. Some learners cut out the shapes and bring to class and we use them based on what they have done. It is an activity-based lesson.

TEACHER 7. I start by showing the charts. Then we also use solid figures and cut out shapes as well. We involve the kids and get them as well.

INTERVIEW WITH TEACHERS

QUESTION 2

How much of hands-on activities do you use to teach geometry?

TEACHER 1: We have a lot of hands-on activities. Like I said earlier we use a lot of cut outs and the children will also be involved in the cutting. Card boards and also things like scissors, blades are used in cutting out the images.

TEACHER 2: We use some of the things we can feel very well in teaching the geometry. We have a lot of teaching aids, and at times we do the whole thing ourselves which we use in teaching so that they can feel the whole thing and it will be very easy for them to explain the whole thing vividly.

TEACHER 3: I believe that using the solid object, they get the understanding of the concept better.

TEACHER 4: There is a chat indicating some angles. For shapes, I ask the t to bring the shapes from home. They can also cut out shapes using the cardboard. We bring them together and study the shapes and their parts.

TEACHER 5: I normally use cut out shapes. And when it comes to lines, I sued things like elastic materials to each them if their hands are moving to the opposite sides, it means they are forming a line. When it comes to the close figures too, we use the cut outs.

TEACHER 6: I make them do the cut outs and we mould them to form the shapes with glues and adhesive tapes. Since it is activity based, I go around and supervise. I correct where necessary.

TEACHER 7: We use the shapes and involve the kids in the activities.

INTERVIEW WITH TEACHERS

QUESTION 3

How do you teach geometry? Is it in abstract? Do you draw the geometrical shapes and figures on the board, or do you ask learners to imagine them?

TEACHER 1: imagination, I don't think that will be helpful in teaching geometry. But like I said, we do a lot of practical work as in the cut out so that the children will have a feel of the regular shapes, rectangular shapes so that they are able to cut it out and then even put them together to form different shapes. It becomes more interesting when you ''practicalise'' it rather than doing it imaginatively.

TEACHER 2: We use some of the things we can feel very well in teaching the geometry. We have a lot of teaching aids, and at times we do the whole thing ourselves which we use in teaching so that they can feel the whole thing and it will be very easy for them to explain the whole thing vividly.

TEACHER 3: I use drawings a lot. I use the physical object and then sometimes imaginations.

TEACHER 4: I use more of drawing on the board and complement it with the shapes around.

TEACHER 5: Geometry is about the environment. So apart from cut outs that I use show them the shapes we also use them classroom rooms and building itself to show them lines and angles.

TEACHER 6: Initially, I ask them to imagine, I bring them some shapes I have made myself and ask them to bring their own shapes as well. These are the shapes we use in teaching and learning to facilitate understanding.

TEACHER 7: We use the charts, the figures which the children handle so they don't imagine.

INTERVIEW WITH TEACHERS

QUESTION 4

Do you display and show your learners 2-D shapes and 3-D objects during geometry lessons?

TEACHER 1: Yes, we do a lot of demonstration. You can it out and then you show it to them. So, they enjoy the lesson. You will be surprised that they want to even build more concepts than what you have even taught them.

TEACHER 2: As I have already said, we have the 2-dimentional and the 3-dimentional shapes. The 3-dimentionals are solid. We have our technical department where the help us prepare these solids. So, it makes it very real and makes the teaching very easy.

TEACHER 3: Yes, I do.

TEACHER 4: Yes. In the case of the cuboid, they just see the 3-D shape of the cuboid.

TEACHER 5: Yes. Apart from using the plain shapes, I normally bring in the solid ones, so they know cubes, and what have you.

TEACHER 6: Yes, I display 2-D and 3-D shapes. Sometimes if you don’t, they don’t learn much.

TEACHER 7: Yes. Depending on the needs of the topic, we display the 2-D and 3-D shapes.

INTERVIEW WITH TEACHERS

QUESTION 5

What is your understanding and perception of the concept of geometry vocabulary teaching?

TEACHER 1: I believe that in every area of life, reading plays an important role so with the vocabulary in geometry, it is very important for the children to understand the vocabulary before they can also apply it.

TEACHER 2: One thing you must know is that, before the children can understand the topic or subject very well, they must know the vocabulary around that particular topic. So, I share the idea that we must the learners to understand it in the subject. We must also explain further for the children to understand the concepts we discuss behind the whole thing, so it becomes very easy and very lively when it is time to learn the subject.

TEACHER 3: I think like any other topic or most of the topics in mathematics, it is a lifelong lesson that one must learn, therefore I believe that children should be taught very well to understand it, so that they can apply it in their everyday life in the future.

TEACHER 4: I think it is a very important key; you can't do away with that. Without it, I believe the learners will be at sea because even for us adults, it's a bit challenging to understand the concept of geometry without understanding the vocabulary associated with the topic. So, I believe it is very necessary.

TEACHER 5: If you don't know the words used in a certain field, you cannot understand it. I personally don't teach it in isolation; I use it when I'm teaching. When it comes to lines, segments, radius and diameter, it comes in when I'm teaching, and I emphasize on them so that they will use it to identify the objects.

TEACHER 6: Teaching vocabulary is a good thing. Sometimes we used the English dictionary to get some definitions. We don't have geometry or maths dictionary in the classroom, but we use the normal English dictionary.

TEACHER 7: The vocabulary is the foundation of the whole subject, so I teach them as and when necessary.

INTERVIEW WITH TEACHERS

QUESTION 6

What is the level of attention and focus you give to mathematics vocabulary teaching during your lessons?

TEACHER 1: You don't have to give them a lot of vocabularies at a go so when you have 15mins of vocabulary is enough to help some of the children understand.

TEACHER 2: One thing is that, if they don't understand the concept very well, and the concept goes with the vocabs around it. Every subject has its own vocabulary. In mathematics, even though we derive the vocabs from English, we should be able to understand the concept so that when the question is asked, they will be able to analyse the question. And when they are able to analyse the question very well, that is when they will be able to solve and appreciate the subject. Certain terms must be understood before the child will be able to learn and then answer questions very well.

TEACHER 3: I love to stress on that as much as possible because that is what makes the learners understand better. It makes them pick up the language of maths and also helps them understand it better especially when you blend that with ordinary English.

TEACHER 4: I give counsel during maths training program that really help in learning the vocabulary. I try that in my class, and I was amazed at the result. It makes the work simpler and you will be surprised that even for some particular topics, teaching the vocabulary covers up future topics. So, I see it to be very important.

TEACHER 5: Maths is a science subjects and so you must get the meaning by using the words. So, if you are teaching it in isolation, you should know when to use the vocabulary else they cannot get the concept well. So, I normally emphasize on that and sometimes too I use it in oral mental drill, asking them to explain for instance what is prime number, natural number, whole number and aid them know all the stuff. I think it helps.

TEACHER 6: It depends on what I'm teaching in mathematics. At a point, they are particular vocabularies you have to let them know so they understand what is going on. Often, I help them get the meaning of the words that may be useful in the learning before we begin the lesson to help them get a deeper understanding as the lesson is going on.

TEACHER 7: In primary six, we teach the lines like perpendicular lines and angles. We also introduce them to polygons. But with the polygons, we teach the names and so on, so they know up to the tenth figure. They also get to know construction of angles in the third term.

INTERVIEW WITH TEACHERS

QUESTION 7

How much of mathematics vocabulary do you teach alongside the teaching of mathematics concepts?

TEACHER 1: That is also dependent on the topic being taught. But on the whole, every topic has its own vocabulary. So, as we teach, we chip in some few vocabularies, but in order not for the lesson to be boring, we don't bore them with lots of vocabularies at a go. We take them one at a time.

TEACHER 2: I cannot really specify them because we have a lot of vocabs that we always give out. Even before we start with the teaching itself, we go around randomly to ask questions and demand answer dealing with mathematics vocabs. E.g., what is an odd number? What is an even number? Mention some of the odd numbers that we have, the range: mentions some of the odd numbers between 70 and 80. All these go with the vocabs. It's important to warm the children up ahead of the subject.

We go in by asking the simple questions on vocabs.

TEACHER 3: I do that sometimes.

TEACHER 4: I haven't done so much. But I try as much as possible to do it when I realize it's needed in the topic. Without it, the learners will find it difficult understanding the topic.

TEACHER 5: It comes in when I'm teaching so I cannot quantify it. It comes in when and where it is necessary for you to use.

TEACHER 6: It depends on what I'm teaching and as and when I have to explain a particular word to the class, then I do that.

TEACHER 7: I am very particular about the words I use in teaching the vocabularies. When they understand, they are able to use them well to their benefits.

INTERVIEW WITH TEACHERS

QUESTION 8

What level of emphasis or details do you observe when teaching geometry vocabulary?

TEACHER 1: The children become very curious when they realize that some the vocabulary, they have read they did not understand it. So, whiles teaching them then you introduce the vocabulary they begin to appreciate the things that they have read, and they are able to understand it and then the concept is also built there.

TEACHER 2: In geometry itself, people find it difficult most of the time because of the drawing aspect so if you don't teach the vocabulary very well, they are not going to appreciate the topic very well. So, you have to chip in the vocabs very well. Ask them questions for them to get informs and the subject becomes very easy.

TEACHER 3: Just like any other topic in the syllabus, I give every topic equal attention and importance.

TEACHER 4: I realized that the learners get to understand the question. So even if they happen to make mistakes, they don't deviate. You realize that the concept and the understanding of the methodology, they get it right. So, it helps make the work a lot easier.

TEACHER 5: Vocabulary is a tool for you to use. Whether it is in languages of science, it is very useful. So, the level of it is more in teaching every subject. Not only in mathematics.

TEACHER 6: It helps because learners follow instructions of what is being taught and enjoy what they do. It makes teaching and learning fun.

TEACHER 7: Yes. Occasionally I allow them to use the dictionary. When there is the need for the use of dictionary, they use the mathematics dictionary.

INTERVIEW WITH TEACHERS

QUESTION 9

What do you consider to be the impact of geometry vocabulary teaching on the performance of learners in primary 6?

TEACHER 1: The impact is that the children will be able to have a better imagination of geometric terms. As in rectangles, quadrilaterals, rhombus, spheres etc. and so if take for example, a building, you even want to whet the appetite with respect to architecture. So if you want to construct a building and you know that it is going to be rectangular in shape, circular in shape, then they will be able to understand it based on the concept that has be built there on the understanding of the vocabulary.

TEACHER 2: The impact is that, when the vocabs are taught very well, the topic becomes very light. Learners will love to draw. They will love to know some of these angles and other things. Performance becomes very high and they're able to learn faster.

TEACHER 3: Ones they get the concept right; they perform very well in that.

TEACHER 4: I think without it, you can't really do well, and the learners would perform poorly.

TEACHER 5: It gives them the idea of shapes or the idea of creating something. So, helps them learn to create not only in mathematics but the creative arts as well.

TEACHER 6: It helps them as a lot of words that the children will have to understand need to be taught and when they know then it better for their understanding.

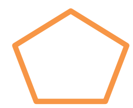
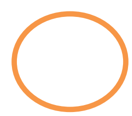
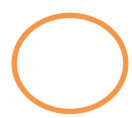
TEACHER 7: It helps them solve the problems very well. Without the maths vocabulary, they cannot do anything.

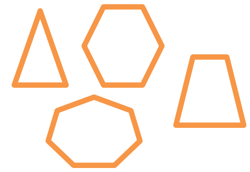
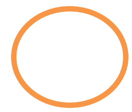
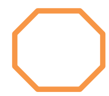
APPENDIX J: GEOMETRY VOCABULARY ACTIVITY SHEET

Name of School: ………………………………………………………… Date: …………………

Class: …………………… Number: …………………

Instruction: Complete the table below. Number 1 has been done for you.

No	**Vocabulary**	**Meaning**	**Example**
1	Pentagon	A polygon with 5 edges (sides).	
2	Acute angle		
3		A line from the centre of a circle to the circumference of the circle.	
4	Diameter		
5		An angle that measures 180°.	
6			
7		An angle that is greater than 90° but less than 180°.	

8	Polygons	Closed shapes with straight edges (sides).	
9	A regular Polygon		
10	Circumference		
11			
12		Formed when two lines meet.	
13	A Right angle		
14	An irregular Polygon		
15		A four-sided figure.	
16		Straight lines that have equal distance between them and can never meet.	

17		An angle that is greater than 180° but less than 360°.	
18	A Vertical line		
19		Distance around a shape.	
20	Perpendicular lines		

APPENDIX K: ETHICAL CLEARANCE FROM UNISA

UNISA university of south africa

COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE

13 April 2016

Ref : **2016/04/13/49998757/13/MC**
Student : Mrs NO Orevaoghene
Student Number : 49998757

Dear Mr Orevaoghene

Decision: Ethics Approval

Researcher: Mrs NO Orevaoghene
Tel: +233267217007
Email: ngozio-evaoghene@yahoo.com

Supervisor: Prof. M.G Ngoepe
College of Education
Department of Mathematics Education
Tel: +2712 429 8375
Email: ngoepmg@unisa.ac.za

Proposal: The influence of mathematics vocabulary teaching on year six primary school students' geometry performance in Ghana

Qualification: D Ed in Educational Leadership and Management

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the research.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 13 April 2016.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX L: PERMISSION

THE INFLUENCE OF MATHEMATICS VOCABULARY TEACHING ON YEAR SIX PRIMARY SCHOOL LEARNERS' GEOMETRY PERFORMANCE IN GHANA.

F105/6 Soula Street

Labone-Accra

12th November 2016

ngoziorevaoghene@yahoo.com.

The Director,

------------ School,

Accra, Ghana.

Dear Sir,

I Ngozi Orevaoghene, am researching with Prof. M.G. Ngoepe, a professor in the Department of Mathematics Education towards a D Ed at the University of South Africa. We have approved bursary from the University for the research titled **'The influence of mathematics vocabulary teaching on year six primary school learners' geometry performance in Ghana'** and we are inviting you to participate in the study.

The study aims to investigate the strategies used in teaching geometry in primary six, teachers' perception on geometry vocabulary teaching, whether or not geometry vocabularies are taught in primary six and the extent to which the teaching of geometry vocabulary influences primary six learners' performance in geometry.

Your prestigious institution has been chosen because it falls within the category of schools which the researcher has chosen for her study. The researcher is interested in privately-owned primary schools.

The study will require all the primary six mathematics teachers in the school and all the primary six learners to complete a questionnaire designed and administered by the researcher. Also, all the primary six learners will complete a basic test of geometry achievement test designed by the researcher. The researcher will carry out intervention by having geometry vocabulary teaching sessions with the primary six learners in the school after the pre-test of basic geometry achievement. The researcher would use various methods namely; direct vocabulary instruction, using a mathematics dictionary to find the meaning of the words, talk about the word, geometry word search and geometry vocabulary card game designed by the researcher to teach the children basic geometry vocabulary after which the researcher will re-administer the basic geometry achievement test. As a follow-up, the researcher will interview the participating teachers and five learners from each school selected at random to find out if the vocabulary teaching intervention had an impact.

The findings of this study will help suggest positive strategies for teaching geometry which will help improve learners' performance in geometry. The findings will also provide information on teachers' perception of geometry vocabulary teaching and the influence of geometry vocabulary teaching on learners' performance in geometry. It will be useful to learners, teachers, policymakers and curriculum developers for future planning of the mathematics curriculum to help improve learners' understanding and performance in geometry in Ghana and other countries.

There is no risk of any sort posed to the learners or teachers in any way, be it physical, psychological or emotional. The feedback procedure will entail writing a detailed report on the study and the outcome which will be sent to the school through the principal.

Thank you for your cooperation.

Yours Sincerely,

Ngozi Orevaoghene

(PhD Student at UNISA)

APPENDIX M: INFORMED CONSENT

LETTER TO PARENTS REQUESTING LEARNERS TO PARTICIPATE IN THIS STUDY

16th January 2017.

The influence of mathematics vocabulary teaching on primary six learners' geometry performance in Ghana.

Dear Prospective Parent of Participant & Prospective Participant,

Please read this letter with your ward.

My name is Ngozi Obiageli Orevaoghene and I am researching with Prof. M.G. Ngoepe, a professor in the Department of Mathematics Education towards a D Ed at the University of South Africa. We are inviting your ward to participate in a study entitled "The influence of mathematics vocabulary teaching on year six primary school learners' geometry performance in Ghana." The researcher is conducting this research to find out better ways of teaching geometry for better understanding. This will help your ward and many other learners of their age in different schools.

This letter is to explain to you what the researcher would like your ward to do. There may be some words you do not know or understand in this letter. You may ask the researcher or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study. The researcher has chosen you and your school to take part in this research because the targeted group for this research are primary six learners in privately-owned primary schools in Accra of which your school is one.

The researcher would like the primary six mathematics teachers and the learners to complete a questionnaire. Next, the researcher will ask the learners to answer a set of 20 questions based on geometry which the researcher calls the test of basic geometry achievement (pre-test). Then the researcher will teach all the primary six learners geometry vocabulary using different methods namely; direct vocabulary instruction, using a mathematics dictionary to find the meaning of the words, talk about the word, geometry word search and geometry vocabulary card game designed by the researcher to teach the primary six children basic geometry vocabulary after which the researcher will administer the basic geometry achievement test again (post-test). As a follow-up, the researcher will interview the mathematics teachers and five selected primary six learners from your school to see if the geometry vocabulary teaching had an impact. You will not write your name on the test papers; however, you will be assigned a number for data analysis. About two hundred and eighty primary six children and eight primary six mathematics teachers will be participating in the study. The entire process will take about five of your mathematics periods during the approved dates. You stand to benefit in gaining new knowledge and helping others through the changes that may be made as a result of the findings of this research. The data collected will be stored in both hard and soft copies for a period of five years by the researcher. Hard copies will be locked away in a filing cabinet in the researcher's office while the soft copies will be stored on a password-protected computer for future research or academic purposes. The hard copies will be shredded, and the electronic copies will be permanently deleted using the appropriate software after it has been used for its intended purpose.

The researcher will write a report on the study but will not make any reference to specific individual numbers or say anything that will reveal anyone's identity. The study does not pose any threat to you in any way. You will only be inconvenienced due to a slight change in your regular mathematics schedule during the approved dates. You do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time. You may tell the researcher if you do not wish to answer any of the questions, no one will blame or criticise you. When the study is completed, the researcher shall give a detailed report of the findings to your principal who will then inform you accordingly.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to the researcher or you can have your parent, or another adult call the researcher on **0267217007**. Do not sign the form until you have all your questions answered and understand what the researcher would like you to do.

Thank you for taking the time to read this information sheet and for participating in this study.

Ngozi Obiageli Orevaoghene

PARENT'S CONSENT TO ALLOW THEIR WARDS PARTICIPATE IN THIS STUDY

(Return slip)

I, ---, confirm that the person asking my consent to allow my ward take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to allow my ward to participate in the study.

I understand that his/her participation is voluntary and that he/she is free to withdraw at any time without penalty.

I am aware that the findings of this study will be processed into a research report, journal publications and conference proceedings, but that my ward's participation will be kept confidential unless otherwise specified.

I agree that my ward should complete the questionnaire, do the test of basic geometry achievement and participate in the geometry vocabulary lessons to be taught by the researcher. I also agree that my ward should do the test of basic geometry achievement again after the geometry vocabulary lessons and finally, I agree to the recording of his/her answers to the interview if he/she is selected.

I have received a signed copy of the informed consent agreement.

Parent's Full Names (please print) --

Parent's Signature Date

Researcher's Name & Surname (please print): **NGOZI OREVAOGHENE**

16th January 2017

Researcher's Signature Date

APPENDIX N: ASSENT LETTER

<u>WRITTEN ASSENT</u>

I have read this letter which asks me to be part of a study at my school. I have understood the information about the study, and I know what I will be asked to do. I am willing to be in the study.

__________________ ____________________ _________________

Learner’s name (print) Learner’s signature Date:

____________________ _________________ _________________

Witness’s name (print) Witness’s signature Date:

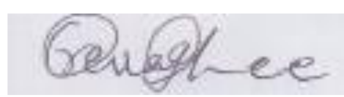
(The witness is over 18 years old and present when signed.)

_____________________ ________________________ Parent/guardian’s name (print) Parent/guardian’s signature:

____

Date:

<u>NGOZI OREVAOGHENE</u>



Researcher’s name (print) Researcher’s signature

<u>16th January 2017</u>

Date

APPENDIX O: ANONYMITY LETTER

LETTER REQUESTING A TEACHER TO PARTICIPATE IN THIS STUDY

Dear ……………………………………………….

This letter is an invitation to consider participating in a study the researcher Ngozi Orevaoghene is conducting. This study is a part of my doctoral research entitled **'The influence of mathematics vocabulary teaching on year six primary school learners' geometry performance in Ghana'** for the degree of D Ed at the University of South Africa. Permission for this research has been given by the Department of Educational Management and the Ethics Committee of the College of Education, UNISA. The researcher has purposefully identified you as a possible participant because of your valuable experience and expertise as a primary six mathematics teacher in the selected school.

The researcher would like to provide you with more information about this study and what your involvement would entail if you should agree to take part. The importance of geometry teaching in mathematics education is substantial and well documented. This research intends to investigate the influence of mathematics vocabulary teaching on primary six learners' geometry performance in Ghana. The researcher would like you to complete a questionnaire at the beginning of this study and participate in an interview at the end. In both the questionnaire and the interview; the researcher would like to have your views and opinion on the mentioned topic. This information can be used to improve the teaching and learning of geometry in primary six in Ghana and other countries.

Your participation in this study is voluntary. Completing the questionnaire will take approximately fifteen minutes and the interview will take approximately twenty minutes in your school during the school day when you are free. However, the entire research period will take up about five of your mathematics teaching periods during the approved dates to enable the researcher to administer questionnaires to the learners, administer the test of basic geometry achievement to the learners (pre-test), teach the learners basic geometry using various methods, administer the test of basic geometry achievement to the learners again (pre-test) and finally interview five of your learners. You may decline to answer any of the questions if you so wish. Furthermore, you may decide to withdraw from this study at any time without any consequences.

With your kind permission, the interview will be audio-recorded to facilitate the collection of accurate information and later transcribed for analysis. Shortly after the transcription has been completed, the researcher will send you a copy of the transcript to allow you to confirm the accuracy of our conversation and to add or clarify any points. All the information you provide will be considered completely confidential. Your name will not appear in any publication resulting from this study and any identifying information will be omitted from the report. However, with your permission, anonymous quotations may be used. Data collected during this study will be retained on a password-protected computer for five years in the researcher's locked office. There are no known or anticipated risks to you as a participant in this study.

If you have any questions regarding this study or would like additional information to assist you in deciding on participating, kindly contact the researcher at F105/6 Soula Street Labone-Accra or call her on **0267217007** or by e-mail to ***ngoziorevaoghene@yahoo.com***.

The researcher looks forward to speaking with you, and thank you in advance for your assistance in this research. If you accept the invitation to participate, the researcher will request you to sign the consent form which follows below.

Yours sincerely,

Ngozi Orevaoghene

CONSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, ---, confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty.

I am aware that the findings of this study will be processed into a research report, journal publications and conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to complete the questionnaire and also to participate in a one-on-one interview in which my answers to the questions will be audio recorded.

I have received a signed copy of the informed consent agreement.

Participant's Name & Surname (please print) ---

____________________ ________________________ Participant's Signature

Date

Researcher's Name & Surname (please print): **NGOZI OREVAOGHENE**

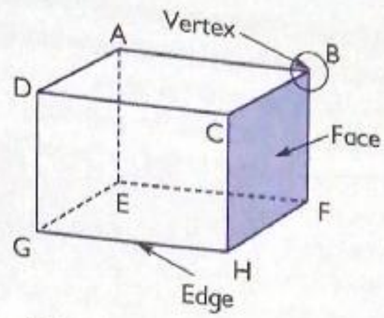
16th January 2017

Researcher's Signature Date

APPENDIX P: NEW MATHEMATICS FOR PRIMARY SCHOOL PUPILS' BOOK 6

...boid

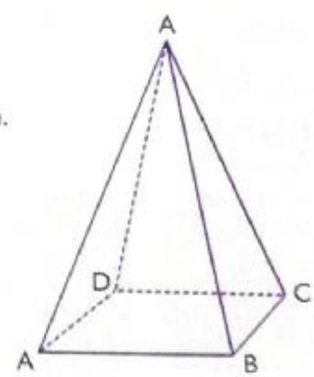
...boid has 6 faces. The faces are labelled.
...D is a face, CHGD is a face and CBFH is a face.
...y the cuboid into your exercise book.
...ne all the 6 faces of the cuboid.
...edge GH is shown on the diagram.
...w many edges are there in a cuboid?
...te down all the edges in your exercise book.
...e vertex of the cuboid has been shown.
...vertex shown is where the line segments or edges $\overline{AB}$, $\overline{CB}$ and $\overline{FB}$ meet.
...w many vertices are there in a cuboid? Explain all the vertices in the cuboid by
...cribing the three edges which meet at the vertices.
...e shape of each face of a cuboid is rectangular.
...ly two faces in our diagram look rectangular, i.e. faces DCHG and ABFE.)
...k at a solid cuboid. You will be able to see that all the faces are rectangles.



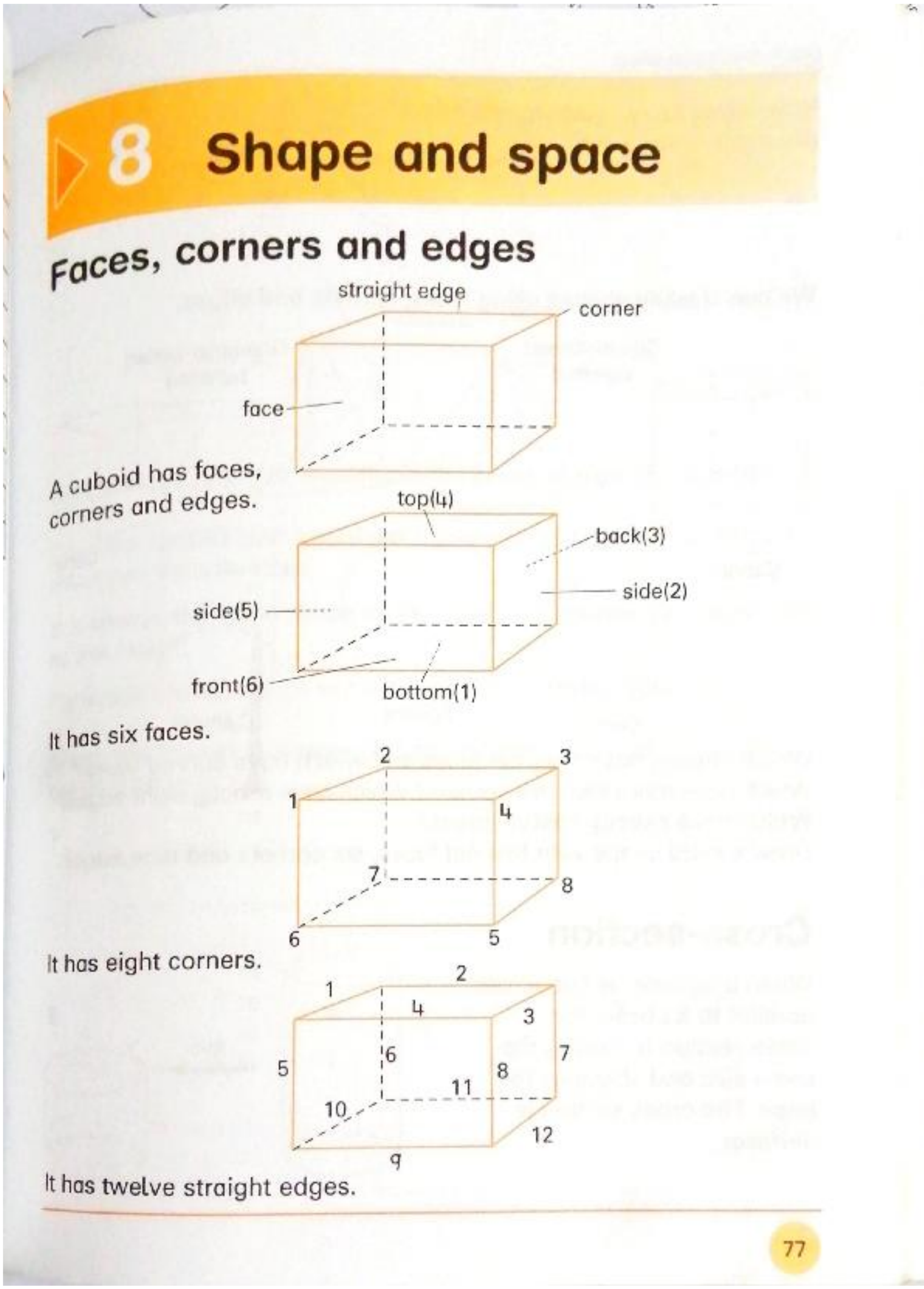
Summary
A cuboid has 6 faces.
Each face of a cuboid is rectangular.
A cuboid has 12 straight edges.
A cuboid has 8 vertices.

...pyramid

...pyramid with a square base has 5 faces.
...opy the pyramid into your exercise book.
...bel the pyramid. Write down the labels to explain each face.
...rite down the shape of each face.
...ow many edges does this pyramid have?
...rite down the labels for the edges.
...rcle the vertices of the pyramid you have drawn in your
...ercise book. Explain the vertices by describing the lines or
...ges that meet at the vertices.



APPENDIX Q: PRIMARY MATHEMATICS PUPILS' BOOK 6



8 Shape and space

Faces, corners and edges

A cuboid has faces, corners and edges.

It has six faces.

It has eight corners.

It has twelve straight edges.

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APPENDIX R: ANALYSIS OF PRE-TEST AND POST TEST

ANALYSIS OF PRE-TEST AND POST TEST

School A: Summary of the comparison of pre-test and post-test scores

School A	Pre-test	Post Test
N	52	52
Mean	6.8173	15.5769
Std. Deviation	3.87049	5.92716
Minimum	1.00	4.00
Maximum	21.00	23.00

School B: Summary of the comparison of pre-test and post-test scores

School B	Pre-test	Post Test
N	89	89
Mean	8.5618	17.7697
Std. Deviation	3.81446	4.78163
Minimum	1.00	4.00
Maximum	17.00	25.00

School C: Summary of the comparison of pre-test and post-test scores

School C	Pre-test	Post Test
N	79	79
Mean	11.0705	16.9241
Std. Deviation	3.90780	4.56652
Minimum	4.00	6.00
Maximum	21.00	24.00

APPENDIX S: PROTOTYPE LESSON PLAN

PROTOTYPE LESSON PLAN – LESSON PREPARATION

STEPS:

1) Gather models of the following 3-D objects; cubes, cuboids, square-based prisms and square based pyramids, triangular pyramids, triangular prisms, hexagonal prisms, hexagonal pyramids, cylinders and cones, octagonal prisms and octagonal pyramids.
2) Prepare and print a worksheet with the nets of these 3-D objects.
3) Prepare and print out a worksheet with pictures of 3-D objects for learners to cut out and paste in their books under the columns: **PRISM OR PYRAMID?**
4) **MENTAL ACTIVITIES**
   a) Mental Starter (Day 1 & 2) GEOMETRY VOCABULARY CARD GAME: **WHAT I'M I?**

   Instructions: Cut out cards on paper. On one side, draw a 2-D shape and under it, write, **WHAT I'M I?** On the order side of the card, write the name of the 2-D shape. On another set of cards, write the properties of each 2-D shape on one side of the card and under the properties, write: **WHAT I'M I?** Write the answer on the other side of the card. These cards are for learners to play with as mental starters.

   b) Mental Starter (Day 3): Prepare 10 mental questions on finding the perimeter of triangles, rectangles and squares. Draw the triangles, squares and quadrilaterals with their dimensions on cards and show the cards to learners and ask them to find the perimeter by adding up the sum of all the sides of the shape.
   c) Mental Starter (Day 4) Prepare 15 mental questions on finding the perimeter of prisms and pyramids. Draw 3 prisms and 3 pyramids with their dimensions on cards and display the cards on the board. Ask learners to find the perimeter of each object by adding up the sum of all the sides. Stop activity after 8 mins and give the correct answers to the class with the aid of the learners.
   d) Prepare a mixed concept mental test for Mental Test on Day 6.

5) VOCABULARY LIST

Write and cut out or type, print and cut out the mathematics/geometry vocabulary list for the week and stick them on a board or wall in an area of the class where learners can easily see and learn the words. Learners can assist the teacher to create this wall.

PRISMS & PYRAMIDS VOCABULARY WALL

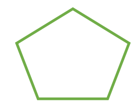
Polygon, solid object, geometrical object, 2-D shape, 3-D object, triangle, square, rectangle, quadrilateral, pentagon, heptagon, hexagon, octagon, **regular polygon**, **parallel lines**, **perpendicular lines**, prism, **parallel faces**, pyramid, faces, edges, vertices, square-base prism, square-based pyramid, triangular-based prism, triangular-based pyramid, **tetrahedron**, pentagonal prism, pentagonal pyramid, hexagonal prism, hexagonal pyramid, **octagonal prism, octagonal pyramid**, trapezium, **trapezoid**, cone, cylinder and **cross section**.

6) Prepare a 3-D vocabulary activity sheet for learners.

3-D VOCABULARY ACTIVITY SHEET

Name: ………………………………………………. Date: ………. Class: ……

Instruction: Complete the table below. Number 1 has been done for you.

No	Vocabulary	Meaning	Example
1	Pentagon	A polygon with 5 edges (sides).	
2		A polygon with all the edges equal.	
3		Straight lines that have equal distance between them and can never meet.	
4	Face	A **face** is a flat or curved surface on a **3D shape**.	
5	**cross section**		
6		Straight lines that meet at right angles.	
7	**octagonal prism,**		
8		4 triangular faces, 4 vertices and 6 edges.	

9	**octagonal pyramid**		
10	**Parallel faces**		
11		A prism that has two top and bottom pentagonal faces and five rectangular faces. It has 7 faces, 10 vertices and 15 edges.	
12	**Trapezium - UK** **Trapezoid - US**	a convex quadrilateral with at least one pair of parallel sides is referred to as a trapezium in English outside North America, but as a trapezoid in American and Canadian English.	
13	A 3-D object	as a solid figure or an object that has three dimensions – length, width and height. Unlike two-dimensional shapes, three-dimensional shapes have thickness or depth.	
14	A hexagonal pyramid		
15		A four-sided figure.	

PROTOTYPE LESSON PLAN

OBJECTIVES	At the end of the week, learners should be able to: 1) Identify and name the various prisms and pyramids. 2) Identify the nets of various prisms and pyramids. 3) Find the perimeter of 2-D shapes and 3-D objects. 4) Differentiate between prisms and pyramids. 5) Give the properties of specific prisms and pyramids. 6) Find the perimeter of 3-D objects/models. 7) Describe prisms and pyramids using appropriate geometry vocabularies.
DATE	
CLASS	Primary 6
SUBJECT	Mathematics
REFERENCE	
TEACHING/LEARNING RESOURCES	Models of the 3-D objects listed above; nets of these 3-D objects; worksheet with pictures of 3-D objects for learners to cut out and paste in books under the columns: **PRISM OR PYRAMID?** Prepare a vocabulary activity sheet for learners, **VOCABULARY WALL.** Prepared worksheets for mental /class activities. **Note:** For each day, the teacher selects the resources needed for the day as required in the daily lesson plan.
CROSS CURRICULAR LINKS	History: The pyramids of Egypt. Art: Drawing 3-D objects.
DURATION	1-hour lesson daily

DAY	PHASE 1: Mental Starter (10 mins)	PHASE 2: Main Teaching Activity (40 mins)	PHASE 3: Plenary (5 - 10mins)
		Note: Throughout this phase, when learners are working, the teacher goes round to supervise learners and check/ mark their work. Learners are allowed to ask questions at any point.	
DAY 1 **Objectives:** At the end of the lesson, learners should be able to 1) identify and name various prisms and pyramids 2) differentiate between a prism and a pyramid **Resources: Phase 1** Prepared geometry vocabulary card game **Resources: Phase 2** models of the following 3-D objects; cubes and cuboids, square-based prisms and square based	**(10 mins)** Play a geometry vocabulary card game: WHAT I'M I? .	**ACTIVITY 1 (5 mins)** Teacher explains the objectives of the day's lesson and shows learners the models of 3-D objects they will be studying. Teacher together with learners give the names of the 3-D objects. **ACTIVITY 2 (25 mins)** Organize learners into mixed ability groups of 4 or 6 learners per group. Give each group of learners a set of models of 3 different prisms or 3 different pyramids to explore. Half the class have prisms and the other half have pyramids. Learners work collaboratively in pairs within their groups using the objects to answer the following questions in their books. 1) How many faces does it have? 2) How many edges does it have? 3) How many vertices does it have?	**What have we learnt today? (5mins)** Teacher ask learners to explain in their own words what they have learnt. Learners ask questions and clarify issues.

pyramids, triangular pyramids etc.		4) Does the top have a face or does it end with a sharp tip? 5) What do you notice about the top face and the bottom face? 6) What do you notice about the side faces of the object? What shape are the side faces? 7) What is the name of your 3-D object? 8) Is it a prism or a pyramid? 9) How do you know? 10) Where can you possibly see the shape of this object in real life? **ACTIVITY 3 (15 mins)** Vocabulary Time: Teacher teach learners the following new vocabulary: **parallel lines, perpendicular lines, parallel faces, regular polygon**, by demonstrating and showing learners examples of these from the models of 3-D objects in the class and from the environment. Learners look for the meaning of these words in their mathematics dictionary, write them and make graphical representations of these vocabularies in their books.	
DAY 2 Same lesson and grouping and activities 1 & 2	**(10 mins)** Repeat geometry	**ACTIVITY 3 (15 mins)** Vocabulary Time: Teacher teach learners the following new	**What have we learnt today? (10 mins)**

from Monday's lesson with time shorter by 5 mins **BUT** learners swap 3-D objects (i.e.) learners who explored prisms on Monday would explore pyramids on Tuesday and vice versa. **HOME WORK:** Teacher gives each learner the vocabulary activity sheet prepared for the lesson to complete as homework.	vocabulary card game: WHAT I'M I?	vocabulary: **tetrahedron, cross section, octagonal prism, octagonal pyramid, trapezium / trapezoid,** by showing learners examples of these from the models of 3-D objects in the class and from the environment. Learners look for the meaning of these words in their mathematics dictionary, write them and make graphical representations of these vocabularies in their books.	Teacher ask the following questions: Who can describe a tetrahedron? (Teacher shows the class a model of a tetrahedron) What is the other name for a tetrahedron? State two differences between a prism and a pyramid. Take a prism and show a pair of parallel faces.
DAY 3 **Objectives:** At the end of the lesson, learners should be able to 1) state the properties of given prisms and pyramids. 2) identify parallel faces of a given prism. 3) identify	**(10 mins)** Prepared mental questions on finding the perimeter of triangles, rectangles and squares.	**ACTIVITY 1 (10 mins):** Teacher gives each learner the prism or pyramid worksheet with pictures of 3-D objects for learners to cut out and paste in their books under the columns: **PRISM OR PYRAMID?** **ACTIVITY 2 (30 mins):** Teacher gives each learner the worksheet with pictures of the nets of 3-D objects for learners to cut out and paste 3-5 prisms in their books. Learners work collaboratively in pairs to write down	**What have we learnt today? (10 mins)** Teacher shows the class a prism they have learnt and ask learners to show the net of the prism and give all the properties.

the nets of given prisms. **HOME WORK:** Teacher gives each group of learners' soft thin wire and tapes to make models of 3-D objects. Each group should make a prism and a pyramid.		the properties of at least 2 prisms and identify 2 pairs of parallel faces in each prism. Higher achievers go on to identify all the pairs of parallel faces in each prism and write the properties of all the prisms.	Learners ask questions and clarify issues.
DAY 4 **Objectives:** At the end of the lesson, learners should be able to 1) state the properties of a given pyramid. 2) identify the nets of given pyramids. **HOMEWORK:** Complete all outstanding work.	**(10 mins)** Prepared mental questions on finding the perimeter of 3-D objects.	**ACTIVITY 1 (10 mins):** With the help of the class, the Teacher go over the vocabulary activity sheet which learners completed for homework on Tuesday. **ACTIVITY 1 (20 mins):** Teacher gives each learner the worksheet with pictures of the nets of 3-D objects for learners to cut out and paste 3-5 pyramids in their books. Learners work in pairs to write down the properties of at least 2 pyramids. Higher achievers go on to cut out, paste and write the properties of all the pyramids. **ACTIVITY 2 (10 mins):** Teacher reviews the properties of the prisms and pyramids, making sure that	**What have we learnt today? (10 mins)** Teacher asks a learner to show the class a pyramid they have learnt and ask learners to show the net of the pyramid and give the properties as they feel confident to respond. Learners ask questions and clarify issues.

		learners write down the correct properties for each prism\ pyramid. Learners who could not complete the task should complete it as homework. **Extension:** Learners who need more challenge go on to find the total surface area of prisms.	
DAY 5 **Objectives:** At the end of the lesson, learners should be able to 1) find the perimeter of any given 3-D object. 2) understand and use geometry vocabulary adequately. **HOMEWORK:** Complete all outstanding work. **Review all the work done on prisms and pyramids and prepare for a Test during the next lesson.**	**Vocabulary Review (15 mins)** The class reviews the geometry vocabulary on the wall and the vocabulary activity sheet. **HOW?** All learners stand and earn their sit by taking turns to explain the meaning of a geometry vocabulary on the wall.	**ACTIVITY (40 mins)** Learners display the 3-D models they constructed for homework for teacher to inspect. Learners compare the properties of their 3-D models with the properties they have written in their books. Teacher with the help of the learners review how to measure and find the perimeter of their 3-D models. Learners find the perimeter of the 3-D models they constructed and of those constructed by their pairs and compare answers. **Extension:** More confident learners begin to calculate total surface area of the 3-D objects of their choice.	**What have we learnt today? (10 mins)** Teacher selects a group of learners to show case their 3-D models, talk about the models, show the properties and how to calculate the perimeter of the models. Learners ask questions and clarify issues.

DAY 6 **Objective:** Teacher assess learners understanding of the weeks' lesson to know how to progress.	**(10-15 mins)** Prepared mixed concept mental test.	**ASSESSMENT (25 mins)** A differentiated assessment to ensure all category of learners can participate and at the same time challenged to achieve. See sample of assessment. **Learner Exploration (10-15 mins):** Learners who complete the assessment before time should further explore any object of their choice individually or in pairs or small groups.	**QUESTION & ANSWER TIME**

APPENDIX T: SAMPLE ASSESSMENT

Instruction: Read each question carefully. Answer all questions and where necessary, show all working in the work space provided.

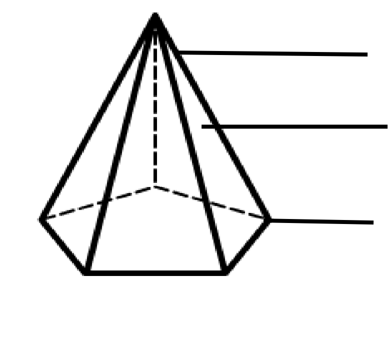
TIME: 30 minutes (Total Marks 25)

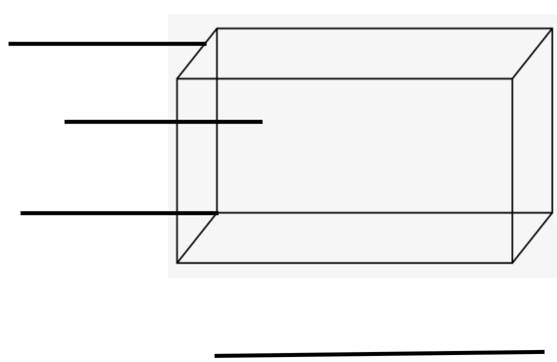
1. a) What is a regular polygon?

A regular polygon is ....

(1mark)

b) Label the parts indicated and write the name of the object in the space provided.





(5 marks)

2. a) The side faces of a pyramid are in the shape of a .... (1 mark)

b) The side faces of a prism are in the shape of a... (1 mark)

3. a) I am a 3-D object. I have 9 faces, 9 vertices and 16 edges. What am I? (1 mark)

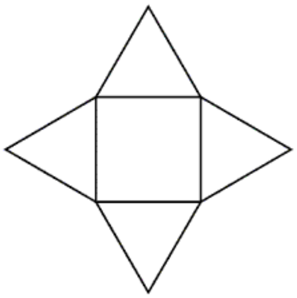
…………………………………………………………………………………………

b) Jeremy has a 3-D geometrical object. It has 6 faces, 12 edges, 8 vertices.

The object could be a ……..........…. or a ……..........…… (1 mark)

4. These are the nets of 3-D objects. Write the name of each object in the space provided.

a)



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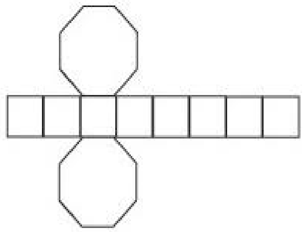
b)



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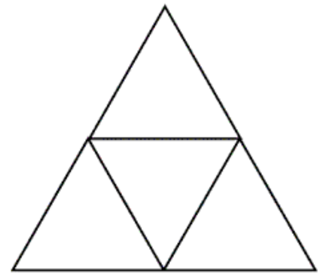
c)



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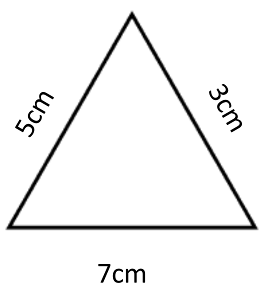
(3 marks)

5) Find the perimeter of the figures below.

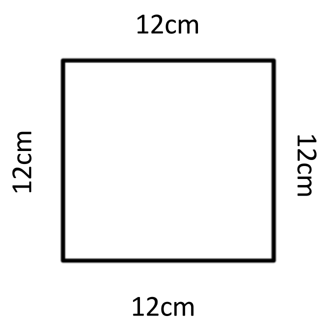
a)



(1 mark)

Perimeter =

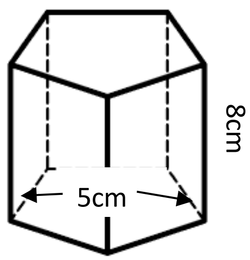
b)



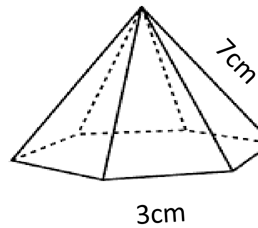
(1 mark)

Perimeter =

c) d)



(2 marks)

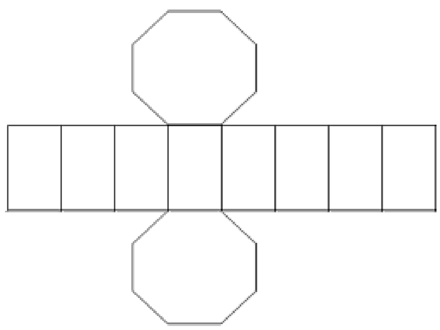


(2 marks)

Perimeter =

Perimeter =

6) This is a net of a 3-D object. On this net colour a pair of parallel faces.



(1 mark)

7) Learners were given a roll of soft wire to make models of 3-D objects.

a) Cecelia made a model of a tetrahedron (a triangular based pyramid). The length of each edge of the model is 9cm. What length of wire did she use to make her model?

(2 marks)

b) Lubanzi used the same length of wire as Cecelia, but he made a regular hexagonal prism. What is the length of each edge of his prism?

(3 Marks)