UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF ICT INTEGRATION ON SENIOR HIGH STUDENTS' MOTIVATION AND ACHIEVEMENT IN GEOMETRY: THE CASE OF GOMOA WEST DISTRICT

JUSTICE YAWSON MENSAH

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JUSTICE YAWSON MENSAH

A **dissertation in the Department of Mathematics Education, Faculty of Science Education, submitted to the School of Graduate Studies, in Partial Fulfillment**

of the Requirements for the Award of the Degree of Master of Philosophy (Mathematics Education) in the University of Education, Winneba

AUGUST, 2019

DECLARATION

STUDENT'S DECLARATION

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

SIGNATURE: …………………………………………………

DATE: ………..…………………………………………………

SUPERVISOR'S DECLARATION

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

NAME OF SUPERVISOR: PROFESSOR M. J. NABIE

SIGNATURE: …………………………………………….......

DATE: ……….…….……………………………………………….

DEDICATION

This thesis is dedicated to my grandfather, Mr. Seth Ababio, for his enthusiasm for knowledge acquisition which propelled me to pursue this postgraduate study.

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It has not been easy putting pieces together to form this whole intellectual work, and I couldn't have done it unaided. It is my pleasure to acknowledge those who in one way or another contributed to the success of this thesis.

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ABSTRACT

This study explored the effect of ICT integration in teaching Mathematics on students' motivation and achievement in endowed and less endowed Senior High Schools (SHSs) in the Gomoa West district of the central region. The study employed the embedded mixed method approach involving quasi-experimental design in which three SHSs (one endowed and two less endowed) were purposively selected and assigned as control and experimental groups. A sample of 120 students and 4 Mathematics teachers from the three schools were randomly selected for the study. Geometry Achievement Tests (GAT) was administered to all student participants as pre-test and after the intervention a similar GAT was administered to students again as post-test. During treatment, ICT was integrated into the lessons of the experimental groups while the traditional instruction was applied to the control group. Six students from the experimental group and 4 mathematics teachers were interviewed to elicit their views on how ICT integration motivate students to study mathematics. Results from paired sample t-test showed that participants in both groups (experimental and control) had increment in their post-GAT as compared to the pre-GAT. However, independent samples t-test results revealed that students in the experimental group achieved better in the post-GAT as compared to those in the control group. Findings also revealed that students from the endowed school outperformed those from the less endowed school. Finally interview results revealed that ICT integration promotes students' motivation by; making the lesson student-centered and practical, promoting retention through its visual presentation and increases students' study time allotted to mathematics. In conclusion, ICT integration approach to teaching and learning of mathematics concepts was found to promote students' motivation and increased achievement in mathematics than the traditional instruction.

CHAPTER ONE

INTRODUCTION

1.0. Overview

This chapter presents the background to the study, the problem statement, the purpose of the study, objectives and research questions that the study sought to find answers to. Other areas covered in this chapter include the significance of the study, the limitations of the study, the delimitations of the study and definitions of the terms used in the study.

1.1. Background to the Study.

The conceptual understanding of mathematics at the Senior High level is indispensable when it comes to pursuing Mathematics and Science related courses at the tertiary level in Ghana. The knowledge in Mathematics is undoubtedly a necessity to the development in most areas of life and the economies of the world. Apart from knowledge in computation, mathematics also helps individual to think rationally and critically through its numerous cognitive components. Because of these numerous benefits derived from the knowledge of mathematics, every country concerned about its development put a great deal of emphasis on the study and effective teaching of mathematics in its school curriculum. However, research has shown that mathematics is one of the difficult subjects in the curriculum and students have difficulties in understanding various mathematical concepts (Mensah-Wonkyi & Adu, 2016). Accordingly, countries all over the world are investing heavily on finding new and effective ways of teaching mathematics to promote achievement, motivate learning and provide equal opportunities for all students from endowed and less endowed schools in the learning process.

Tay and Mensah-Wonkyi (2018) in a recent study found that one of the new ways of teaching mathematics that promote higher achievement, motivate learning and improve performance of students in endowed and less endowed schools is the integration of Information and Communication Technology (ICT). The process of ICT integration began more than a decade ago and countries all over the world are at different stages of ICT integration. ICT integration in education was previously considered a thing of the developed countries but this phenomenon has changed over the years and developing countries are striving to match the international standards in ICT integration (Agyei, 2013; Tilya, 2008). According to Bourne (2017), current advances in technology and the role that technological tools play in society and the digital word today, makes it imperative for curriculum developers to incorporate ICT integration in school curricula.

From 2002, the Ministry of Education and Vocational Training (MoEVT) of Tanzania endorsed that ICT should not only be taught as a subject, but also be integrated as a pedagogical tool for teaching and learning in subject areas, especially mathematics and science (as cited in Kayyulilo, Fisser & Voogt, 2015). The situation in Ghana is not different when it comes to integration of ICT in mathematics education at the senior high school level. The SHS mathematics curriculum require mathematics teachers to help students to use technology for problem solving and investigations of real life situations. Mathematics teachers are also required to make students develop interest in studying mathematics to a higher level in preparation for professions and careers in science, technology, commerce, industry and a variety of work areas (Ministry of Education [MOE], 2010)

The numerous benefits derived from the integration of ICT in education has seen many African countries investing heavily in ICT infrastructure to make the integration possible (Igun, 2013). In Ghana, ICT integration into education as evidenced in several policies and documents such as, The Ghana ICT for Accelerated Development (ICT4AD) Policy (2003), ICT in Education Policy (2008), ICT in Education (2015) and several others. For example, the ICT in Education policy specifically stated "ICTs can be used to transform the teaching and learning systems to meet the challenges of the knowledge economy" (Ministry Of Education, 2008, p. 21). The education reforms that hit the pre-tertiary level in 2007 saw ICT and its integration introduced in schools requiring students in pre-tertiary institutions in Ghana to acquire basic ICT literacy skills and apply them in a variety of ways in their everyday life activities (Curriculum Research and Development Division [CRDD], 2007). Also, initiatives by various governments to expand ICT infrastructure and access, especially in senior high schools is a further evidence of Ghana's efforts to promote ICT integration in the educational sector. For example, the e-readiness assessment report conducted by the Ministry of Education, in 2009, indicated that the number of schools having access to computer lab was relatively high as about 87% of all senior high institutions are reported having at least one computer laboratory (Ministry of Education [MOE], 2009).

A number of research studies have indicated that effective integration of ICT into mathematics education has positive influence on students' academic achievement as well as on students' motivation to learn mathematics (Ghavifekr et al, 2014; Ron, 2009). Furthermore, when ICT is integrated into mathematics education, it has the tendency of putting all students on the same level in terms of motivation and thereby leading to academic improvement (Bhagat & Chang, 2015). In their study, Bhagat and

Chang (2015) used GeoGebra as an intervention strategy to teach a concept in geometry and found that students in the experimental group outperformed those in the control group, indicating that GeoGebra (ICT tool) is an effective tool for teaching and learning geometry. Typical Ghanaian public SHS classrooms are characterized by students from different backgrounds, environments and learning styles. ICT being an equilizer (Bhagat & Chang, 2015), can put all these students on the same level to study Mathematics and hence promoting equity in the learning process. Several similar studies involving incoporating ICT in teaching of Mathematics concepts found positive impact on students' academic achievements (Eyyam & Yaratan, 2014; Tay & Mensah-Wonkyi, 2018; Zengin, Furkan & Kutluca, 2012).

Teacher training is a necessary factor for successful integration of ICT in mathematics education. The Mathematics curriculum of teacher training universities in Ghana, whose core mandate is to train mathematics teachers for the SHS level, has ICT integration as a major component of the curriculum. For instance, it is a general knowledge that the programme description for both undergraduate and post graduate mathematics education at the University of Education, Winneba (UEW), require mathematics teachers to take and pass six courses in ICT at the undergraduate level and two courses at the post graduate level before graduation. This presupposes that mathematics teachers from these institutions are equipped with the necessary skills and competences in ICT integration before becoming practicing teachers. This claim is supported by the findings of a tracer study conducted by four lecturers at the department of Mathematics Education of UEW on a sample of 48 in-service mathematics teachers of UEW which found that about 96% of participants were aware of ICT integration in mathematics education but only 42% were actually integrating ICT in their teaching and learning process (Asiedu-Addo, Apawu, Owusu-Ansah &

Armah, 2016). Research has also shown that, mathematics teachers are the most conversant with ICT in educational institutions (Chao, 2015). This implies that mathematics teachers have the potential to employ ICT into the teaching process more than any other subject teachers.

In spite of the ICT integration policies in Ghana and the numerous benefits ICT integration play in teaching and learning, as well as the availability of computer laboratories in most secondary schools, a number of studies conducted in Ghana to ascertain the level of ICT integration indicate that most Ghanaian teachers in general and mathematics teachers in particular do not integrate ICT in their teaching and learning process (Agyei, 2013; Agyemang & Mereku, 2015; Fredua-Kwarteng & Ahia, 2005).

Studies (Agyei, 2013; Bhagat & Chang, 2015; Marbán & Mulenga, 2019; Tay & Mensah-Wonkyi, 2018; Zengin et al., 2012) principally focused on investigating the effects of using a particular ICT tool in teaching a particular concept in mathematics, factors affecting ICT use in schools, pre-service and in-service mathematics teachers' preparedness to integrate ICT in the teaching process, teachers attitudes towards ICT integration into mathematics education, etc. Limited progress has been made on the general effects of using ICT in mathematics education on students' motivation and achievement in mathematics in endowed and less endowed SHSs in a comprehensive manner, especially in Ghana. Hence the need for more research on the effects of integrating ICT in teaching and learning of mathematics. This study focused on investigating the effects of integrating ICT in teaching and learning of mathematics on achievement in mathematics of students from both endowed and less endowed SHSs and motivation to learn mathematics in the Ghanaian classrooms.

1.2. Statement of the Problem

The abysmal performance of SHS students in core mathematics at the end of their contact years in school has been of grave concern to stake holders at this level of education. Statistics from the West African Examinations Council (WAEC) shows that the percentage of students who obtain pass grade (A1– C6), in core mathematics , since its inception in 2006, has been below 50% for school candidates who sat for the West African Senior School Certificate Examination (WASSCE) in Ghana. Also, WAEC chief examiner's reports for core mathematics 2 (WAEC, 2015; WAEC, 2016; WAEC, 2017; WAEC, 2018) consistently report of students' difficulties and abysmal performance in geometry, particularly the concept of Mensuration. For instance the 2018 WAEC chief examiners report for core mathematics 2 categorically stated that candidates demonstrated weakness as difficulty in "solving problems involving Mensuration" (WAEC, 2018, p. 230). Furthermore, there is empirical evidence that many students in Ghana face severe difficulties in solving questions involving geometry concepts (Baffoe & Mereku, 2010). This suggests that SHS students find geometry concepts difficult and mathematics teachers are faced with the challenge of how to present geometry concepts to students to promote conceptual understanding.

Studies (Abreh, Owusu & Amadahe, 2018; Kalhotra, 2013; Sa'ad et al., 2014) into the causes of these abysmal performances of students in mathematics especially WASSCE in the sub-region, have identified inappropriate or poor teaching strategies employed by mathematics teachers, lack of motivation on part of the students to study mathematics, poor entry grades and school factors such as lack of facilities as some of the causes. Less endowed SHSs are the most affected in terms of these causes. Most Less endowed schools in Ghana apart from deficiency in infrastructure, are populated by students with very poor entry characteristics, such as poor grades in Basic Education Certificate Examination (BECE). The commitments of various governments to improve performance of students and the quality of education through ICT integration as evidenced in several ICT integration policies cannot be overemphasized. This is reflected in the educational policies in Ghana, recognizing ICT as a powerful tool that cannot be left out in the education of its 21st century generation (ICT4AD Policy, 2003; ICT in Education Policy, 2015; MOE, 2010). Also there is evidence to show that various mathematics teacher training institutions are investing heavily in equipping their products with ICT integration abilities and competencies in order to use ICT in their teaching (Asiedu-Addo et al., 2016). Furthermore, many research studies (Eyyam & Yaratan, 2014; Tay & Mensah-Wonkyi, 2018; Zengin, Furkan & Kutluca, 2012) have established that ICT integration into teaching and learning of mathematics has positive influence on students achievement and motivation.

However, many mathematics teachers in Ghana do not integrate ICT in their lesson delivery as evident in many reports and research studies (Agyei, 2013; Agyemang & Mereku, 2015; Amanor, 2014; Dziekpor, 2014; Mensah, 2017). In a study conducted in the Ashanti region, Agyemang and Mereku (2015) found that only 19.9% of mathematics teachers in the region integrated ICT into teaching of the five areas of mathematics that they measured. This finding implies that most mathematics teachers still use "chalk and talk" instructional approach in teaching which makes students passive listeners. This method of teaching in the 21st century does not motivate student learning and it is found to be among the major factors contributing to the abysmal performance of SHS students in mathematics, particularly in WASSCE (Abreh et al., 2018; Mullis, Martin, Foy & Arora, 2012; Sa'ad et al., 2014,). The failure of most mathematics teachers to integrate ICT into teaching and learning of mathematics in the Gomoa West district is not different as observed by the researcher in his many years of teaching in the district.

Mathematics teachers' failure to integrate ICT in teaching and learning of mathematics in Ghanaian SHSs may be due to lack of confidence among mathematics teachers in utilizing ICT in curriculum delivery (Agyei, 2013) or might be due to mathematics teachers' unawareness of the potentials of ICT in their teaching (Ndebalima, 2014). Mathematics teachers' lack of confidence in integrating ICT in teaching according to Buabeng-Andoh (2012), may be traced to the teacher's doubt in whether integrating ICT in teaching would lead to improved academic performance in mathematics and also motivate students to learn mathematics. According to Buabeng-Andoh (2012), for teachers to integrate technology effectively into their teaching, they need to be assured that technology can bring about improved teaching and learning, motivate students and make lessons more enjoyable hence the current study explored the effect of ICT integration (particularly, the use of PowerPoint designed lessons) on the achievement and motivation in Mensuration of SHS students' in both endowed and less endowed schools in the Gomoa West district.

1.3. Purpose of the Study

The traditional method, where mathematics teachers stand in front of students and explain concepts to them using chalk/marker and board and then give examples from textbooks, employed in the teaching of mathematics concepts makes students passive listeners and deficient in active participation. This method of teaching in the 21st century does not help students across the country to improve their conceptual understanding in the mathematical content domain as indicated in several research studies (Abreh et al., 2018; Sa'ad et al., 2014; TIMSS, 2011 as cited in Mullis et al, 2012). Hence the purpose of this study is to explore the effects of integrating ICT in teaching and learning of mathematics concepts on the achievement of students in both endowed and less endowed SHSs and on their motivation to learn mathematics. Specifically, the study was designed to explore the effects of using ICT and its tools as a strategy of teaching the Mensuration I concept in mathematics on SHS students' achievement in mathematics and motivation to study mathematics in the Gomoa west district. The study further sought to explore the achievements of SHS students from endowed and less endowed schools who were both exposed to ICT integration method of teaching Mensuration I.

1.4. Objectives of the Study

This study was designed to achieve the following objectives;

1. To examine the effectiveness of ICT integration on SHS students' academic achievement in mathematics.
2. To determine the extent to which ICT integration can bridge the gap in the achievement of SHS students in endowed and less endowed schools.
3. To determine the effects of ICT integration on SHS students' motivation to study mathematics.

1.5. Research Questions:

The research was intended to address the following research questions:

1. What is the effect of ICT integration on SHS students' achievement in mathematics in contrast to the traditional method?
2. To what extent does ICT integration bridge the gap in the achievement of students in endowed and less endowed SHSs?

3. In what ways do ICT integration motivate students to study mathematics at the SHS level?

1.6. Significance of the Study

Every educational institution in the 21st century is striving to produce graduates with necessary and sufficient skills in order to fit into the demands of this dynamic world where ICT plays a crucial role. Mathematics education all over the world is now becoming activity-based and student-focused rather than the chalk-and -board approach to teaching and learning. In Ghana, it is required that one obtains a grade not lower that C6 in WASSCE in core Mathematics to be able to gain admission into any tertiary institution. The abysmal performance of SHS students in core Mathematics for the past decade have been of great concern to stakeholders in education. The statistics show that students from less endowed schools, who are mostly from lower socio-economic backgrounds, routinely score lower grades than their counterparts from endowed schools. Integrating ICT and its tools into teaching of mathematical concepts may be a great equalizer by providing the same level grounds for students from both endowed and less endowed schools to learn mathematics with hands-on approach and a great motivator. This study explored the effects of ICT integration on SHS students' achievement in mathematics and motivation to study mathematics in the Gomoa West district of the central region of Ghana.

Findings from this study will assist stakeholders in the district to make informed decision on whether integrating ICT in mathematics education can increase the rate of SHS students that pass core mathematics, in WASSCE. Findings will also assist in setting education reform policies and develop strategies that can be used to improve the delivery of mathematics concepts to students in the district and the country as a whole. Findings from this study would also inform the decision of mathematics educators and policy makers about the effects of ICT integration in mathematics education and the best strategy to use in delivering mathematics concepts to improve SHS students' achievement. This will enable appropriate measures to be instituted to support successful ICT integration in mathematics education. Furthermore, the study will add to the stock of research materials on the effects of ICT integration in mathematics education. It will be useful to researchers seeking information related to the effects of ICT integration into mathematics education in schools and also inform them through the recommendations and other related areas worthy of further research.

1.7. Delimitations of the Study

Delimitations are the boundaries set or choices made by the researcher in the conduct of a research (Simon, 2011). For the goals of this study not to become impossibly large to complete, the following delimitations were set:

Gomoa West district in the central region was selected out of a total of 20 districts in the central region and a total of 254 districts in Ghana. This district was selected purposively because of its special characteristics for the objectives of the study. It was also selected because the researcher has worked in the district for many years and the problem of study was identified during that period.

Secondly, the population of the study consisted of SHS 2 students in the district. Even though there are many levels of education in Ghana (Pre-school, Kindergarten, basic, SHS, Vocational and Technical, Tertiary, etc.), the study only focused on the SHS 2 students. SHS 2 was the only level used because of the area in mathematics that the study investigated. The findings thus cannot be generalized for all levels of education in Ghana.

Furthermore, the sample used in this study were selected using systematic random sampling technique. Even though there are many sampling techniques, the researcher used systematic sampling because it enabled the researcher to select samples from each stream using class registers or lists without disrupting contact hours. Systematic sampling was also adopted because of its simplicity in selecting samples from large population.

Also, the study considered only one concept in Geometry; Mensuration 1 (area and perimeter of plane shapes). Even though SHS students find other concepts in geometry difficult, only this area was chosen as a result of abysmal performance of students every year as evidenced in WAEC chief examiners' reports (WAEC, 2016; WAEC, 2017; WAEC, 2018) for core mathematics. Also, only this area of the curriculum was selected due to time constraints. Most importantly, the study was not concerned about coverage but knowledge. The results was concluded based on this aspect of mathematics and might not be same for other aspects in mathematics.

Finally, not all ICT tools were integrated into the intervention process. Participants in the experimental group were exposed to lessons prepared in PowerPoint using selected ICT tools in mathematics (Geogebra, derive 5, paint and geometers sketch pad). Only the experimental group had access to computers that have the PowerPoint presentation on them after each session of the intervention. These ICT tools were used because of the geometry concept in mathematics (mensuration) that the study addressed.

1.8. Limitations of the Study.

Limitations of a research are the influences or factors that the researcher cannot control that place restrictions on the methodology (Simon, 2011).

Three public SHSs used in this study were purposively selected out of one district of Ghana. They were selected purposively because they are the only schools in the district that possess the special characteristics (one endowed school, two similar less endowed schools) that the researcher was looking for. The results thus cannot be generalized for all districts in the central region or Ghana at large. This limitation was reduced when all students in these three schools were admitted through GES's CSSPS. This has enriched the population used for the study in terms of SHS students' abilities, cultural and social backgrounds. The SHSs used therefore represents the characteristics of Ghanaian SHSs in any part of the country.

Also, the sample size was only limited to 120 respondents out of a total of 1775 SHS2 students. This sample size was selected for reasons of practicality of the study. The sample size thus, is too small to make a general conclusion for all SHSs in the country. The consequence of this was that, generalization of the research findings was limited. This limitation was alleviated when the samples from each school were selected randomly. The sample used therefore represents the characteristics of all students in SHS 2 in the district.

Furthermore, Geometry Achievement Test (GAT) was used as a test instrument for data collection. The test was administered twice as pre-test and post-test intended to measure the attainment of students in Mensuration I (area and perimeter of plane figures). The result of this was that an individual's score on the first administration of the test may influence the scores on the second administration. This limitation was reduced by constructing different but similar items for pre-test and post-test.

1.9. Operational Definitions

In the context of this study, the following definitions of terms used in the study are given based on the objectives, scope, limitations and delimitations of the study.

Information Communication Technology (ICT): ICT is a very broad term that encompasses a diverse set of technological tools and resources used to communicate, create, propagate, store, and manage information. For the purpose of this study, United Nations Educational, Scientific and Cultural Organization's (UNESCO) definition of ICT will be adopted. UNESCO defined ICT as:

> ICT refers to forms of technology that are used to transmit, process, store, create, display, share or exchange information by electronic means. This broad definition of ICT includes such technologies as radio, television, video, DVD, telephone (both fixed line and mobile phones), satellite systems, and computer and network hardware and software, as well as the equipment and services associated with these technologies, such as videoconferencing, e-mail and blogs. (UNESCO, 2007, p. 1)

Students' Achievement: Student achievement refers to the amount of academic content learned by a student within a specified amount of time. The achievement can be measured using various assessment tools such as achievement tests, observation or interview.

Motivation: For the purpose of this study, Schunk, Pintrich and Meece (2014) definition of motivation will be adopted. They defined motivation as "the process whereby goal-directed activity is instigated and sustained" thus motivation is inferred from actions and requires activity, physical or mental, geared towards goals.

Endowed SHSs (ES): Endowed SHSs are those SHSs which have adequate infrastructure necessary for teaching and learning. These infrastructures include classroom blocks, computer laboratories, boarding facilities, science laboratories, etc. These schools are mostly located in urban communities and populated by students who obtain good Basic Education Certificate Examination (BECE) grades.

Less endowed SHSs (LES): Less endowed SHSs are those SHSs which have inadequate infrastructure necessary for teaching and learning. These schools are mostly located in rural communities and populated by students from low socio-economic backgrounds who performed abysmally in their BECE.

Traditional/conventional Method of teaching: For the purpose of this study, the traditional method of teaching mathematics is defined as the process by which mathematics teachers explain concepts to students by using board illustrations and then follow the explanations up with examples from textbooks. Here, the teacher may use other teaching and learning materials apart from ICT tools in the process of explaining concepts to students.

CHAPTER TWO

LITERATURE REVIEW

2.0. Overview

This study investigated the effects of integrating ICT in teaching and learning of mathematics on students' motivation and achievement in endowed and less endowed SHSs in the Gomoa West district. This chapter provided reviews of literature based on the research questions. Taking into account, the purpose and objectives of the study, this chapter is organized chronologically on the following thematic areas.

- Theoretical framework
- ICT integration in education in Ghana
- Students difficulties in Geometry
- Factors affecting students' achievement in mathematics.
- Motivational effects of ICT integration in teaching and learning of mathematics
- Effects of ICT integration on students' achievement in mathematics
- ICT integration as an equalizing tool.

2.1. Theoretical Framework

From literature, the most widely used theories in the field of ICT integration on students' achievement are the Constructivist theory (Bhagat & Chang, 2015; Tay & Mensah-Wonkyi, 2018; Zengin et al., 2012) and the Engagement theory (Kearsley & Shneiderman, 1999; Marshall, 2007). The two theories share many features in terms of student-centered approach to teaching. Engagement theory is used as the theoretical base underpinning this study.

Engagement Theory (ET) is a framework for technology-based teaching, whose fundamental underlying idea is that students must be meaningfully engaged in learning activities through interaction with others and worthwhile tasks (Kearsley & Shneiderman, 1999). This theory shares many features of the constructivist theory. The ET encourages teachers to use practical activities to encourage students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about it. However, proponents of the engagement theory believe that "technology can facilitate engagement in ways which are difficult to achieve otherwise" (as cited in Marshall, 2007, p.109). Engagement theory promotes students activities that involve cognitive processes and students are motivated to learn due to the conducive learning atmosphere that technology creates. According Kearsley & Shneiderman (1999), ICT environment is the best teaching and learning environment that provides a meaningful and authentic experience for students and can stimulate the kinds of experiences students will face outside the classroom.

Engagement Theory comprises three components:

1. Relating: learning activities that occur in a group context (collaborative work). This forces students to clarify and verbalize their problems to facilitate solutions. It emphasizes teamwork and communication
2. Creating: Learning activities that are project based. Students are involved in the development of their assessment tasks and apply ideas in specific context. It emphasizes creativity and purpose.
3. Donating: learning activities that have an outside or authentic focus. Students make useful contributions during task. This motivates students because they are occupied with activities throughout (Kearsley & Shneiderman, 1999).

Engagement theory underpins this study because of its emphasis on providing a collaborative and meaningful experience as well as motivation for students in a technology-enhanced learning environment. That is even though students' engagement could be achieved through other means, ICT integrated environments promotes more engagement of students than any other as explained by the engagement theory. The theory was also used because it states explicitly that technology should be integrated in instructional delivery to promote students' engagement.

2.2. ICT Integration in Education in Ghana

Historically, the integration of ICT in teaching and learning in formal education in developing countries was first introduced in the 1970s by some panaceas for education in developing countries such the World Bank and UNESCO but could not stand the test of time due to challenges like lack of electricity, cost, climate, resistance from local teachers, language barrier and cultural issues (Bates, 2014) . In Ghana, emphasis on ICT integration into education started in 2003 when the Ghana ICT for Accelerated Development (ICT4AD) policy statement was drafted. The policy among other objectives sought to "promote an improved educational system within which ICTs are widely employed to facilitate the delivery of educational services at all levels" (Government of Ghana, 2003, p.8). Since the introduction of this policy statement efforts have been made by various governments to take critical steps in streamlining energies towards integrating ICTs into the educational system at all levels. This led to formulating a specific policy for the integration of ICT in education (ICT in Education Policy) in 2008 by the Ministry of Education (MOE) following the educational reforms that hit the pre-tertiary sector in 2007. The government was then hopeful that the integration of ICT in education would alleviate the traditional rote learning and prepare students for the challenges associated with the 21st century:

> It is the government's desire that through the deployment of ICT in Education, the culture and practice of traditional memory-based learning will be transformed to education that stimulates thinking and creativity necessary to meet the challenges of the 21st Century**.** (Ministry of Education, 2008, p. 4)

The policy document sought to inform stakeholder on the role of integrating ICT into education and why ICTs are important part of the society (Ministry of Education, 2008).

In August 2015 the then minister of education, Professor Naana Jane Opoku-Agyemang assented to a reviewed policy to reflect the state of the times. The reviewed policy served as a platform to launch a systematic ICT integration in Educational delivery in the country and sought to alleviate the use of the traditional method of teaching in Ghanaian classrooms and promote student centered and collaborative learning through the deployment of ICT:

> It is the Government's desire that through the deployment of ICT in education, the culture and practice of traditional memory-based learning will be transformed to education that stimulates critical thinking, creativity, collaboration and communication necessary to meet the challenges of the 21st century. (Ministry of Education [MOE], 2015, p. 4)

Among the seven guiding principles and objectives of the policy document was incoporating ICTs into curriculum. This gives the gudeline to how ICT can be integrated in education to harness its full potentials. The policy stands on three pillars, one of which is "ICT as integrated into the teaching and learning" (MOE, 2015, p. 18). This pillar sets the way for subject teachers and stakeholders in education to make it possible for ICT to be integrated into all subjects within the national curriculum. It also allows stakeholders to create the opportunity and employ educational technology tools in the teaching and learning of all subjects at all levels of the educational ladder in the country. The Policy direction makes room for teachers preparation and in-service training to adequately prepare them to develop the right and appropriate skills as well to adapt to changing situations and best practices. Also, this pillar is focused on creating condusive learning environment for the students to be able to appreciate and adapt to the use of ICT in teaching the subjects in their syllabi.

From the literature it is clear from history that ICT integration in education in Ghana has been with us since time immemorial. Also, there exist a national policy on ICT integration in education to create condusive teaching and learning environments to promote student-centered and collaborative learning.

2.3 Students' Difficulties in Geometry

Geometry is one area in the SHS curriculum that students struggle to answer problems on. The difficulties that students face in geometry does not start at the SHS level but has been with the students from earlier stages of their education. Baffoe and Mereku (2010) conducted a study in which they measured the Van Hiele levels of geometric thoughts attained by SHS1 students on entering SHS. The study employed the survey approach using the Van Hiele Geometry Test as instrument to collect data from a sample of 188 students from two schools in Winneba. The results indicated that 59% of the participants reached level 1, out of which 11% reached level 2 and only 1% reached level 3 of the theory. These results suggested that over 90% of Ghanaian students from the Junior High School (JHS) could not logically order the properties of plane figures and their relationships before entering the SHS.

The difficulties that students face in geometry explain why most SHS students have difficulties in solving problems involving the Mensuration concept which requires students' prior knowledge in properties of geometric shapes. It is therefore not surprising that the West African Examination Council (WAEC) chief Examiner's reports for core mathematics 2 paper for five consecutive years (2014-2018), consistently report of students' difficulties in solving problems involving geometry, particularly the Mensuration concept (WAEC, 2014; WAEC, 2015; WAEC, 2016; WAEC, 2017; WAEC, 2018). The remedy this abysmal performance in geometry, the chief examiner for core mathematics suggested in his report in 2016 that mathematics teachers take the necessary steps to make their teaching more practical as well as relate their teaching to real life situations to motivate students to appreciate the subject (WAEC, 2016). Subsequently, mathematics teachers were again advised the following year, to make their teaching lively and interesting in order to gain students' interest in the subject (WAEC, 2017). ICT integration into teaching geometry may be the sure way to put all these suggestions into practice. A study conducted by Abu and Abidin to test the effectiveness of Geometry learning Video on 180 students who were at the bottom of the Van Hiele Geometric Thinking level, found a significant improvement in geometric thinking level of majority of the participants (Abu & Abidin, 2013).

In another study, Alex and Mammen (2012) investigated the levels of geometric thinking among 191 grade 10 learners in South Africa. Using a test on Van Hiele's level of geometric thinking as instrument to collect data, the study found that majority of the participants were at level 0 of the theory. This suggests that the problem of students' difficulty in geometry is not only a Ghanaian problem but a worldwide affair.

The difficulties students encounter in the study of geometry are largely attributed to the way geometry is taught in school. According to Armah, Cofie and Okpoti (2017), most students learn geometry by memorizing geometric properties rather than by exploring and discovering the underlying properties. This study explored the effect of integrating ICT into teaching and learning of Mensuration on SHS students' motivation and achievement in endowed and less endowed schools in the Gomoa West district.

2.4. Factors Affecting Students' Achievement in Mathematics.

To put this study in context, this section of the review looks at the factors that affect students' performance in mathematics especially at the SHS level. The rationale is to uncover the role of ICT integration in addressing these factors.

Several studies (Abreh et al, 2018; Bosson-Amedenu, 2018; Kalhotra, 2013; Sa'ad et al, 2014) that investigated the causes of the abysmal performance of SHS students in WASSCE found among other factors, poor teaching methods, lack of motivation, students' entry grade and school factors such as lack of facilities.

Between the periods 2007 - 2018, more than 50% of SHS graduates could not get admission to any tertiary institution in the country because they did not obtain the pass grade (A1 – C6) in Core Mathematics in the WASSCE (Abreh et al., 2018; WAEC, 2018). The major contributing factors to this grotesque academic performance of SHS students include poor teaching methods, lack of interest in mathematics, lack of facilities and low entry grades. A study conducted by Abreh, Owusu and Amadahe (2018), investigated the trends in the WASSCE performance of SHSs in Ghana over a period of ten years and the factors accounting for the abysmal performance. The study employed the exploratory survey research design as method of enquiry to establish the trend in WASSCE performance over a decade (2007 – 2016) and also to identify some of the perceived factors influencing the trend. They used a sample of 170 SHSs out of 875 SHSs countrywide selected using proportionate stratified sampling technique. The sample consisted of the head teacher, one mathematics teacher, one science teacher and ten students from each of the 170 SHSs. Using data from WAEC and questionnaire instruments the findings revealed among other factors lack of interest in Mathematics and teachers' teaching methods as contributing factors to the abysmal performance. The findings also revealed that the trends did not provide a definite pattern of performance but the average performance of students over the period was below 50% and high percentage of students acquired grade F9.

In another study which investigated among other things, the greatest contributing factors to the mass failure in core mathematics in Ghana, Bosson-Amedenu (2018) found students' weak foundation (entry grade) as one of the major contributing factors. the questionnare data collected from 42 mathematics teachers in the Takoradi municipality of the Western region indicated that about 81% of the mathematics teachers were of the view that students' weak background was a major factor cotributing to the abysmal performance in the WASSCE.

The story is not quite different in other countries which write the WASSCE. A study conducted in Sierra Leone by Gegbe, Sundai and Sheriff (2015) on the topic "Factors Contributing to Students Poor Performance in Mathematics at West African Senior School Certificate Examination (WASSCE)", explored school-based, demographic-based and student personal factors that affect students performance in WASSCE among the sample used. The study, adopted a descriptive survey research design, where a sample of 115 respondents which comprised of 100 WASSCE students and

15 Mathematics teachers selected from five (5) secondary schools in Kenema District, were used. The schools were selected purposively, while the particpants from the selected schools were randomly selected.

The findings revealed among other factors, teachers' teaching strategies, low socio-economic background and lack of motivation of students in mathematics as some of the major causes of students abysmal performance in mathematics. The study also indicated that participating students interviewed, enter SHS with a mean BECE aggregate of 5 in mathematics. Hence these students enter less endowed SHSs with the same low foundation in mathematics and that partly explained why there is still low achievement in the WASSCE. Specifically, they found that 7% of the teachers interviewed still use lecture method, which makes students passive listeners in the teaching and learning process. Even though some of the mathematics teachers interviewed said they use either discussion, discovery or question and answer methods, which many research studies found to be very effective strategy of teaching mathematics, there was no mention of any teacher integrating ICT into the teaching and learning process. This might be a reason why students continue to perform abysmally in the WASSCE. Also, Mathematics textbooks were found as most available teaching and learning material available to the 5 schools used in the study. Also, about 73% of the parents of the students included in the study do not have education beyond secondary school, which indicated a very low socio-economic background of students. Integrating ICT into the teaching and learning process could put these students on the same level as their counterparts from high socio-economic backgrounds. Among students factors leading to poor performance, the researchers found that lack of motivation to study mathematics was a major factor. Again, integrating ICT, could motivate the students and help them to develop positive attitudes towards mathematics.

Furthermore, a study conducted in Nigeria by Sa'ad et al. (2014) on the topic "The Causes of Poor Performance in Mathematics among Public Senior Secondary School Students in Azare Metropolis of Bauchi State, Nigeria" revealed similar factors. The researchers used a larger sample of 300 high school students and 61 mathematics teachers, selected by proportionate stratified random sampling technique. The study employed the descriptive survey design and the main instrument used in data collection was a self designed questionnares involving two Likert scale formats. The data collected was analyzed using frequency and simple percentage.

The researchers found that 85% of the repondents agreed that lack of motivation and negative attitudes of students toward the study of mathematics cause poor performance in the subject among public SHS students. However, the same percentage of students were of the opinion that developing positive attitude and motivation and providing proper guidance to students can help in improving their performance in mathematics. Also, 78% of the students were of the opinion that poor teaching strategies employed by teachers cause poor performance among public SHS students. However, 83% were of the opinion that using appropriate methods of teaching, particularly methods that focus on the student can help in improving the performance of students in the subject. These findings are consistent with the findings of Ogundele, Olanipekun and Aina, (2014) who conducted a review paper focusing on poor academic performance in the WASSCE in Nigeria. These results showed that majority of mathematics teachers still use inappropriate teaching methods and there is evidence of lack of motivation to study mathematics at the SHS level

Many other research studies (Kalhotra, 2013; Mbugua et al. 2012) beyond the boundaries of WASSCE, found similar causes of mass failure of high school students in mathematics. Mbugua et al. (2012), in a study conducted in Kenya, explored the factors contributing to students' poor performance in mathematics at kenya certificate of secondary education to establish the strategies that can be adopted to improve performance in Mathematics by students in secondary schools. The study employed the descriptive survey method using 1876 respondents including 1718 secondary school students, 132 mathematics teachers and 26 headteachers from 26 secondary schools. They found that 5.6% of the teachers use lecture method of teaching while the rest use either discussion, project, discovery or question and answer method of teaching mathematics. Other findings made included factors such as lack of motivation to study mathematics and low socio-economic status of students contributing to the failure of students in mathematics. On the same vein, (Kalhotra, 2013) conducted a study to identify the cause of failure in mathematics among high school students in India using a sample of 125 students who have failed their mathematics examination. The study employed descriptive survey design using questionnare as main instrument for data collection. Among other findings, the study found that teachers use inappropriate teaching method expecially the "chalk and board" method. Only a small number of the students liked their teachers' method of teaching and students lack interest in the study of mathematics. Majority of the students were also found to come from low socio-economic background. The authors suggested that teachers may be given certain refresher courses to expose them to appropriate methods of teaching to promote students' participation and interest in mathematics.

Preliminary literature review suggests that, very few studies have examined the effect of ICT integration in mathematics education on SHS students' achievement and motivation to learn mathematics, especially in Ghana. The available literature also failed to consider the effects of ICT integration on students' achievement in endowed and less endowed schools. Research studies that were conducted elsewhere, suggests that the studies be carried out in other jurisdictions and school systems (Example: Eyyam & Yaratan, 2014). The aim of this study is to fill this gap in the literature and examine the effect of ICT integration in mathematics education on students' achievement in mathematics and motivation in endowed and less endowed SHSs.

2.5 Motivational Effects of ICT Integration in Teaching and Learning of Mathematics

Motivation plays a critical role in the mathematics classroom. When students have the zeal and readiness to study mathematics, about half of the work of getting the concept down to the student is done. Numerous studies have shown that mathematics performance is strongly related to students' motivation towards mathematics learning (Mullis, Martin, Foy & Arora, 2012; Pantziara & Philippou, 2013; Tarmizi & Tarmizi, 2010; Yu & Singh, 2016). It's therefore not surprising that most older and recent studies attribute students' low academic performance in mathematics to lack of motivation and interest in the subject. As such, mathematics teachers play a very important role of providing a motivating environment that will encourage students to excel in the mathematics classroom.

As far back as 1994, Bakare investigated the causes of poor performance of Nigerian students in WASSCE and argued that students' lack of interest in the subject and low achievement motivation are among student factors leading to poor academic performance (Bakare, 1994). Aremu and Sokan, (2003) conducted a similar study in the same country and found same results as Bakare did in 1994. These results suggest that the problem associated with students' lack of interest in mathematics resulting in abysmal performance in the subject has been with us since time immemorial.

It is therefore not surprising that recent studies on causes of poor performance in mathematics find similar results. A study conducted in Sierra Leone, investigating the causes of Sierra Leon students' abysmal performance in WASSCE, found that lack of motivation to students to study mathematics at that level was a major cause of students' poor performance in the examination (Gegbe, Sundai & Sheriff, 2015). Also, while investigating the factors contributing to students' poor performance in mathematics at Kenya certificate of secondary education using a population of 1876 respondents, Mbugua, et al. (2012) found that most of the respondents used (students, mathematics teachers and head teachers) suggested that motivation of students in the subject would lead to improved performance. Furthermore, in a study conducted in India, about the causes of failure in mathematics at the high school level, Kalhotra (2013) found among several factors that majority of the students used for the study (about 78%), lack interest in mathematics and are therefore not motivated study the subject.

It is therefore not surprising that students enter into the tertiary level with the same problem of poor performance resulting from lack of interest and motivation in mathematics. The findings of a study on factors contributing to the poor performance in mathematics of 100 level hundred students of St. Theresa's College of Education in the Volta region, revealed that lack of interest in mathematics was a major factor that contributed to the mass failure of students in their first examination in mathematics at the college (Kumah, Akpandja, Djondo & Kumi, 2016). This suggests that the problem associated with lack of interest in mathematics at the SHS level must be tackled with urgency as it is extending to the tertiary level of education.

It can be deduced from the above literature that if students have the motivation and interest to study mathematics, their academic performance would be improved and vice-versa. Available literature on ICT as a method of teaching, suggest that effective ICT integration into mathematics education, motivate students to learn mathematics and hence improves academic performance of students.

A research report published by Lancaster University on a study conducted by (Passey & Rogers, 2004), reported the numerous motivational effects of integrating ICT into education. A sample of 17 schools from across England, including 5 primary, 8 secondary, 2 special schools and 2 Pupil Referral Units were selected for the study. The sample was further broken down into 121 head teachers, teachers and classroom assistants, 22 parents, 1,206 pupils, as well as 24 youth and community workers, health workers, careers officers and police officers. The sample was collected from a wide range of characteristics including socio-economic background, school phases and types, geographical locations, locality, ethnic backgrounds of pupils, and ICT facilities deployed. Data were collected using questionnaires designed to cover eight different measures and both qualitative and quantitative analysis were employed. Observations were also made in 33 classrooms.

The results show that ICT integration has several motivational effects on students. Some of the motivational effects identified in the findings include students concentrating on the learning process rather than a mere completion of tasks, offering a means for a range of pupils to envisage success, better behavior of students towards the learning process especially when ICT is integrated in teaching other subjects, etc.

Furthermore the results show that all secondary teachers interviewed were of the view that ICT had a positive impact upon students' interest and attitudes towards school work:

> All secondary teachers interviewed indicated that they felt that ICT had a positive impact upon pupils' interest in and attitudes towards school work. They felt that ICT helped pupils to take pride in their work, that it was helpful for coursework, it supported research, that pupils were taking a genuine interest in the quality of their work, and that it was more likely that a task would be completed and on time. Some teachers felt that it did depend upon what was being done, but that interest was stimulated even if sometimes content was not affected (Passey & Rogers, 2004, P. 4).

Similarly, in the report of the 33rd annual conference proceedings of the Mathematics Education Research Group of Australia, (Sparrow, Kissane & Hurst, 2010) argue that students had positive attitudes toward Mathematics but lack the intrisic motivation for the subject. In their study, they investigated the mathematical attitudes and achievement of 984 junior college students in Singapore using the three types of motivation; amotivation, intrinsic motivation and extrinsic motivation. The study was intended to fill the gap of scarcity of studies that investigated students' attitudes toward mathematics and its relationships with academic achievement in Singapore. The conference paper presented the findings of a pilot study on Singapore junior college students' attitudes and achievement in mathematics, using test as instrument for data collection.

Their results showed that students had positive attitudes towards mathematics, which was different from the findings of other reported studies which found negative attitudes of students towards mathematics in the same country. The results from other instruments used indicated that students had high extrinsic motivation (external rewards and punishments) towards mathematics but significantly low intrinsic motivation towards mathematics. Furtheremore, the findings indicated that there exist negative correlation between mathematics anxiety and amotivation and academic achievement. Also there was a positive correlation between achievement and intrinsic motivation but on the contrary, there was no correlation between extrinsic motivation and achievement. The authors suggested that more should be done by stakeholders in education to motivate students intrisically in oder to improve academic performance of students in mathematics. This according to the authors can be done by creating chances for students to have control over their own learning environments and making students complete mathematical task by themselves. The authors suggested that future researches be done in more than one school in Singapore and others parts of the world as the study was conducted in just one Junior College school in Singapore. The current study explored the ability of ICT to motivate students in the SHS in studying mathematics in Ghana.

Furthermore, a more recent study conducted by (Wong & Wong 2017) on students' motivation towards mathematics in a technology-enhanced environtment support the numerous claims that students are more motivated to learn mathematics when technology is appropriately integrated in the teaching and learning process. The study reviewed the existing literature on multiple facets of motivation construct in mathematics learning in Technology-enhanced Learning (TEL) environment. The review concluded that technology is a potential tool for motivating students to study mathematics. The review also noted that TEL can be used to enhance students' self-efficacy as most of the literature reviewed point to self efficacy as a core determinant of students' motivation in mathematics. However, the authors were quick to add that whether or not technology can be used to enhance motivation in TEL depends on several considerations such as the novelty effects of technology. They suggested that the novelty effects of technology be carefully controlled in future research design to ensure that they do not affect the level of students' motivation. They also suggested that the integration of technology alone cannot take care of motivation and learning in theTEL environment hence the teacher or instructional designer has the duty to ensure that the integration is done in such a way that it would promote motivation in TEL environment. This study suggests that eventhough technology has the potential of enhancing students' motivation in mathematics, a mere integration of technology may not promote motivation hence the need to integrate technology in a more appropraite manner. The current study follows this direction by integrating ICT into the teaching of the concept of mensuration I at the SHS level to explore its motivational effects on students.

In another study conducted by Bettice (2012), on how students can be motivated in the mathematics classroom in order to create a more effective learning environment, it came to light that students are motivated to learn mathematics by a number of factors including collaborative work, engaging students in a lot of activities and group work, all of which ICT integration offers. A sample of 25 high school students from Indiana in the United States of America were used for the study. Questionnare which was made of closed and open-ended questions was used to collect data. The results revealed that collaborative work, engagement and group work are major determinants of students' motivation in learning mathematics. Thus most of the students' responses to the questionnare indicated that the above listed determinants contributes a lot to their motivation in the mathematics classroom. In the concluding part, the researcher stated that "students are motivated by their own internal goals and positive outside influences" (Page 2) which ICT integration can help achieve. The participants used for this study was limited in terms of setting and sample size, the current study improved upon this limitation by selecting larger sample size from a wider coverage.

It was clear from the above literature that motivation and students' achievement in mathematics go hand in hand. Mathematics teachers therefore have the responsibility of employing effective teaching strategies that promote motivation of students in the mathematics classroom. The review of literature has shown that ICT integration in mathematics education, as a teaching strategy, has the potential of motivating students in the mathematics classroom. The current study explored the motivational effects of ICT integration in teaching and learning of mathematics at the SHS level in the Gomoa west district of the central region.

2.6 Effects of ICT Integration on Students' Achievement in Mathematics

Several research studies (Bhagat & Chang, (2015); Eyyam & Yaratan, 2014; Tay & Mensah-Wonkyi, 2018; Zengin, Furkan & Kutluca, 2012) conducted across the globe find integration of ICT as a method of teaching mathematics more effective than the traditional method of teaching mathematics. This claim is justified by several research studies conducted across world especially in the western part of the globe.

Bhagat and Chang (2015) conducted a study to explore the impact of incoperating the geogebra software into the teaching of geometry on 9^{th} grade students' achievement in mathematics. They identified that researchers in previous studies used the geometers' sketch-pad software, which is not able to provide multiple representations, and hence using Geogebra which provides multiple representations would fill that gap in previous studies. They also identified lack of evidence in previous studies about the availability of technology in schools in India and hence presented an overview of the availability of technology in schools to fill the gap. The study employed a quasi-experimental research design approach involving purely quantitative data. A sample size of 50 ninth grade students from government schools in India, comprising 25 experimental and 25 control groups were used. Data was collected using pre-test and post-test. The post-test underwent validity and reliability tests and was administered after intervention. Data collected were analyzed using Statistical Package for the Social Sciences (SPSS) where one-way Analysis of Co-variance (ANCOVA) was used to test if there was any significant difference in achievement between the experimental and control groups at a significance level of 0.05.

The findings were that students in the experimental group, who were taught geometry with the Geogebra software, outperformed those in the control group who were taught geometry using the traditional method in the post-test. According to researchers, the results are consistent with the findings of several researchers, which showed a positive effect of using technology in teaching geometrical concepts. The authors also found that ICT could be used to bridge the social divide as it was observed that the intellectual and conception skills of the students in the experimental group were improved.

Among their suggestions, the authors argued that lack of internet connectivity should not be an excuse for mathematics teachers not integrating ICT into their lessons delivery since there are a lot of mathematics softwares and ICT tools which do not require internet connectivity. They suggested that Geogebra, which does not require internet connection to function, should be used in developing countries and remote areas which has no or limited internet connectivity in order to bridge the gap between schools in those areas and those in urban centers. According to them, Geogebra has the tendency of minimizing the technological gap between a teacher and mathematics teaching and suggested that curriculum developers should consider integrating the software into the mathematics curriculum. They suggested that future researchers should investigate the integration of Geogebra with other learning theories such as the constructivism and future research should also consider the professional development of teachers in Geogebra.

In a similar study, Zengin, Furkan and Kutluca (2012) conducted a study in which they investigated the effects of using the geogebra software in teaching trigonometry functions and its graphs on students' achievement. The study employed quasi-experimental research design using purely quantitative data. The sample size for the study consisted of 51 students attending high school in Turkey. The sample was divided into experimental and control groups in which 25 were in the experimental group and the rest in the control group. A pre-test conducted before intervention indicated no significant difference in the achievements of the groups. Both experimental and control groups were taking through a five week intervention teaching with those in the experimental group taking through lessons arranged with geogebra embedded in the computer assisted teaching while those in the control group were taking through lessons designed with the constructivist approach. A post-test developed by the researchers themselves was used to collect data at the end of the intervention stage. Data obtained from both pre-test and post-tests for both groups were analysed using independent sample t-test in SPSS.

Analysis of collected data from both pre and post-tests of both groups indicated an improvement in the results of both control and experimental groups after the intervention. Participants in the control group were more successful on the post-test ($\bar{x} = 54.09$) than on the pre-test ($\bar{x} = 38.86$) while the experimental were more successful on the post-test ($\bar{x} = 72.39$) than on the pre-test ($\bar{x} = 38.86$). An

Independent t-test comparing the post-test results of the two groups indicated a significant difference in the mean achievement of the two groups. The finding indicated that students who were taught trigonometry using the dynamic mathematics software, GeoGebra performed better in their achievement as compared to students who were taught lessons in the constructivist instruction.The results implied that eventhough constructive intructional approach could lead to improvement in students achievement, integrating ICT into teaching of mathematics would lead to more improvement in students' achievement. That is, their findings revealed a positive effect of teaching with constructivist approach on students' academic performance of the control group but a more significant improvement in the academic performance of the students in the experimental group, where lessons were taught using the geogebra software.The findings suggested that eventhough constructive approach in teaching mathematics could lead to improvement in the academic performance of students, employing ICT in the same regard could lead to more significant improvement in academic performance of high school students.The authors suggested in their concluding notes that blending computer assisted instructions with constructivist approach is more effective than the constructivist approach employed in isolation.

This study was carried out in just one high school, with a sample of 51 students and one ICT tool (Geogebra) was employed in the intervention process. The study was also conducted in Turkey to measure the impact of the treatment on achievement of high school students in trigonometry. The current study was conducted using a sample of three SHSs in Ghana using various ICT tools to investigate the impact of integrating technology in Mathematics education on the achievement of students in Mensuration.

In the same vein, a similar study conducted two years later in the same country (Turkey) by Eyyam and Yaratan (2014), using a quasi-experimental research design, investigated the impact of technology use in Mathematics lessons on students' achievement and attitudes. They used 3 experimental groups of 41 participants each and 2 control groups also of 41 participants each from a private secondary school in Turkey for the study. Just like the study by Meng and Idris (2012), the researchers did not engage in the intervention process themselves but equiped the teachers, who regularly teach mathematics to these existing classes, to teach both the experimental and control groups during the intervention stage. All the teachers for both the experimental and control groups were provided with lesson plans, all necessary materials, and pre- and post-tests but lessons for teachers in the experimental group were designed with technology integrated (laptop with multimedia and a data projector transferred to PowerPoint slides and videos, pictures, flash cards, animations, etc.). Pre-test and post-test were used to collect data to measure the impact of technology use on students' achievement.

The results from the one-way analysis of covariance (ANCOVA) conducted by the researchers show that students in the experimental group, where technology was employed, obtained higher marks in the post-test than their counterparts in the control group. Thus just as found in the study of Zengina et al. (2012), the researchers found a significant positive impact of integrating technology into the intervention process on students' achievement $F(1,73) = 7.12, p = .024 > .05$). In addition, the researchers found that students who took part in the study showed positive attitudes towards the use of educational technology which consequently led to a positive effect on their performance. They also found improvement in students' attendance to class because of the use of technology. Based on the results, the researchers recommended that technology integration be incoperated into teacher training and technological equipments and tools be provided to teachers in order to reap the so many benefits that comes with technology integration. They also recommended that using educational technology for teaching mathematics in similar education systems around the globe be investigated to see if similar results would be obtained. The current study investigated the impact of integrating technology into mathematics education on students' achievement in Ghanaian SHSs.

Again, Safdar et al. (2011), conducted a study on the effectiveness of ICT in teaching mathematics at secondary level. The study employed ICT integration as a strategy of teaching as an intervention and the traditional method of teaching mathematics as a control and then measured the difference in participants' performance. The population for the study was 39,760 students in 637 institutions affiliated with Federal Board of Intermediate and Secondary Education, Islamabad studying mathematics in the ninth grade out of which sample of one hundred and twenty students (120) studying mathematics in the ninth grade at two selected public and private schools were selected. The study employed quasi-experimental research which used a quantitative research design approach using test instruments for data collection. The researchers used the scores of the sample at the end of their class VIII as pre-test. They then performed an intervention, where ICT was integrated to teach the experimental group while the traditional approach was applied to the control group, after which a post-test was conducted for both groups. The researchers did not carry out the intervention by themselves but trained two mathematics teachers in the experimental schools to use ICT in the intervention process. The reliability of the post-test was measured using the split-half method.

The results indicated that ICT integration was least effective in the academic achievement of students in the experimental group from the public school but very effective in the academic achievement of students in the experimental group from the private school in mathematics at secondary level. The difference in the findings of the two categories of schools used (public and private) was attributed to the non-availability of the technological facilities at school or at home or due to lack of knowledge/interest in using the technology at the public sector and vice-versa at the private sector. The researchers summarily concluded that integrating ICT into teaching mathematics on students' academic achievement was significant in the private school but insignificant in the public school. One clear shortcoming of this study which could have led to the difference in the results was the usage of two different trained teachers in the intervention. The researcher believed that even if two different people are given the same training they would still possess different abilities, hence they employed the services of different trained teachers in the two schools. In the current study, the researcher himself carried out the treatment in all the three schools used for the research.

In her conference paper "Using technology to support effective mathematics teaching and learning: What counts?" delivered at a research conference at the university of Queensland, Goos (2010) described the extent to which technology integration and policy might complement each other leading to effective mathematics teaching in Australian schools. This article was a conference paper which did a meta-analyses of published research works on technology and its effectiveness in mathematics education. The presenter analyzed several researches on the subject matter using a quantitative, formal, epidemiological study design to systematically assess the results of previous research to derive conclusions about that body of topic.

The meta-analysis of existing researches and the brief research summary and classroom snapshots show that technology can transform students' mathematical knowledge and practices. Despite the above significance of ICT integration, the author noted that there is gap between intended curriculum and what mathematics teachers actually implement in terms of ICT integration in Australian schools. She however, noted that many teachers are already integrating technology successfully to enhance their students' understanding of mathematics and also motivate their students to study mathematics. She concluded that in the hands of these teachers "lies the task of enacting a truly futures-oriented curriculum that will prepare students for intelligent, adaptive and critical citizenship in a technology-rich world" (Page 70).

Furthermore, Meng and Idris (2012), conducted a more in-depth study into the effects of phase-based instruction using manipulatives and Geometer's Sketch Pad (GPS) based on the van Hiele theory from Level 1 to level 3. The study employed case study research design, using a sample of 8 (4 males and 4 females) form one secondary school students, selected purposively, from Malaysia. The samples were purposively selected from a secondary school that has a computer laboratory equipped with a teacher's laptop, an LCD projector, sufficient computer equipment and facility. The case study design employed, gave the researchers the opportunity to make a thorough investigation into whether students' geometric thinking and achievement in solid geometry could be enhanced through phase-based instruction using manipulatives and GSP based on the van Hiele theoretical framework. The researchers used an adapted interview instrument and solid geometry achievement test, developed based on participants' mathematics syllabus, to collect data for analysis. The test was administered as pre-test, to determine participants' achievement in solid geometry prior to intervention, and then re-administered as a post-test after a three week teaching intervention. Interview data were audiotaped and transcribed and each transcript was analyzed. For the solid geometric achievement test, a paired-samples t-test was computed by the researchers using SPSS version 13 to ascertain if there was any significant difference in the pre-test and post-test scores of the test.

The results showed that before treatment, all the participants could only recognize and name solids (cubes and cuboids in particular) and also distinguish cubes from cuboids, which is level 1 of Van Hiele's Levels. After the intervention (using GPS, an ICT tool), the results indicated that about 75% (6 out of 8) of the participants progressed from level 1 to level 3 of the levels showing a significant improvement in achievement. The other 2 of the 8 participants, who were described by the researchers as "low ability students", progresses to level 2. The results from the paired-sample t-test also indicated statistically significant difference in the means of the pre-test and post-test scores indicating that phase-based instruction using manipulatives and GSP enhanced the students' achievement in solid geometry. This research study used manipulatives and an ICT to investigate their effect on students' achievement in solid geometry based on Van Hiele's levels. It is therefore difficult to ascertain which one of them contributed more to the academic achievement or if both methods contributed equally. The current study addressed this by employing only one strategy (ICT integration) as treatment to investigate the effect of that strategy on academic achievement of SHS students in solid geometry.

Also, a study conducted in India, using Geogebra mathematical software in the intervention process found results similar to that of Zengina et al. (2012) and Eyyam and Yaratan (2014). The study was conducted by Bhagat and Chang (2015), employing quasi experimental research design involving a sample of 50 students comprising of 25 experimental and 25 control participants from a government middle school in India. The researchers themselves were involved in the intervention process where participants in the experimental group were instructed using geogebra software while those in the control group were instructed using the traditional method in circle geometry. The researchers used students' summative assessment test as pre-test and developed a post-test which was a Mathematics Achiement Test (MAT) containing 10 multiple-choice questions, based on the objectives in their mathematics syllabus on circle geometry. Data collected from the MAT was analysed using one-way Analysis of Co-variance in SPSS to test if there was any statistical significance difference between the experimental group and the control group.

The results from the analyses showed that students in the experimental group out-performed their counterparts in the control group showing a significant difference in the teaching strategies $F(1, 47) = 16.103$, $p < .05$. The researchers also observed that ICT integration led to an improvement in the reasoning and conception skills of the students in the experimental group. The researchers used multiple representations as their theoretical framework, they suggested that further research be carried out to integrate ICT tools with other learning theories like constructivism and computer supported collaborative learning.

In Ghana, research studies that exist on technology integration mostly explored the effects of a particular technology (ICT tool) on the academic acievement of students' achievement and motivation. Several studies in this area found positive effects of ICT integration into mathematics teaching and learning on the academic achievement of Ghanaian SHS students in contrast to the traditional method of teaching mathematics . A recent study conducted by Tay & Mensah-Wonkyi, (2018) explored the effects of incoperating the geogebra software into teaching and learning of circle theorems on the academic performance of SHS students. The study employed quasi-experimental design, specifically using non-equivalent quasi-experimental design. The sample for the study were two intact classes (total of 49 students; 25 in experimental group and 24 in control group) selected from two purposively selected SHSs from the Twifo Hemang Lower Denkyira District and Agona East district of the central region. The two intact classes were selected randomly from the two schools; one from each district. The researchers used equivalent geometry achievement tests constructed by themselves for both pre-test and post-test as instruments for data collection. According to the researchers teacher-made achievement test was perfered due to its numerous benefits. Hypothesis was tested using Analysis of Covaraiance (ANCOVA) and performance of students in both groups in the pre-test and post-test were described using descriptive statistics such as means, standard deviations, percentages, tables and Box plot.

The results showed that students in the experimental group, who were exposed to lesson on circle theorem by incoperating geogebra as a teaching strategy, improved significantly in the post-test as compared their counterparts in the control group taught by the traditional method. Specifically, the results indicated that the mean score increased from 9.40 in the pre-test to 28.36 in the post-test results of the experimental group while the mean score for the control group increased from 9.67 to 10.13. The unprecedented increase in the performance of students in the experimental group was as a result of the integration of geogebra. Also, the paired sample t-test conducted to compare the pre-test and post test scores of the students taught with the GeoGebra teaching approach, indicated a statistically significant increase in the students' achievement from the pre-test to the post-test, $t(24) = 11.382, p < 0.0001$. The sample-test also indicated a significant difference in the pre-test and post-test results of the students taught by the traditional method (control group); $t(23) = 7.332, p = 0.0001 < 0.05$. The results from the ANCOVA, testing for any significant difference in the two teaching methods showed a statistically significant main effect on the students who used GeoGebra to learn Circle Theorems, $[F(1,46) = 27.944; p = 0.0001 < \alpha = 0.05]$. This results indicated that the students who were taught circle theorems with geogebra performed better than those taught the same concept with the traditional approach. The study concluded that integrating ICT tools (especially geogebra) into mathematics education is one of the solutions to the abysmal performance of students in geometry, especially circle theorems. The researchers suggested organisation of seminars and workshops for teachers in SHS on the use of appropriate technological tools to teach difficult concepts in mathematics especially geometry. The literature suggests that limited effect studies on ICT integration exist in Ghana. Those that are available did not consider the effect of ICT integration on students' achievement in various categories of SHSs (endowed and less endowed). This study sought to fill this gap in literature.

2.7 ICT Integration as an Equalizing Tool

SHS students' performance in mathematics in less endowed schools in the central region and Ghana as a whole, as compared to their counterparts in the endowed schools is nothing to write home about. Statistics from WAEC indicates that less endowed schools are always among low performing schools each time WASSCE results are released (WAEC, 2018). These schools (less endowed schools) lack basic facilities such as well stock libraries and laboratories necessary for teaching and learning. To add to their woes, most students in these schools enter with very low BECE grades as compared to their counterparts in the endowed schools. Also, majority of the students in these schools (less endowed) come from low socio-economic backgrounds and poor communities, whose parents or guardians had very low or no formal education. Many studies (Adamu & Sadiq, 2014; Gegbe & Sheriff, 2015, Gitaari & Nyaga, 2013) have found these attributes of students in the less endowed schools (low entry grade, low-socio economic background, lack of facilities and uneducated parents/guardians) as contributing factors to their poor performance in mathematics as compared to other students in the endowed schools.

In a study which investigated the factors contributing to students' poor performance at WASSCE in Sierra Leone, Gegbe & Sheriff, (2015) found that students' low entry grades and students' parents or guardians education background were among other factors contributing to the poor performance of students in WASSCE. The study which employed non-experimental, exploratory and descriptive design used a sample size of 115 respondents including 100 students and 15 mathematics teachers selected from five low performing public secondary schools. Questinnaires and face-to-face interviews were instruments used to collect data. The results specicifally showed that about 73% of the parents/gurdians of the students involved in the study do not have education beyond secondary school hence do not actively engaged in the education of their children. According to the authors, this could be a demotivation to the students since their parents may not serve as role models for them. Also they found that the average BECE entry grade in mathematics these students enter into secondary school with was 5 which explained the poor performance of students in mathematics.

Another study was conducted by Gitaari and Nyaga (2013) to explore the factors contributing to students' poor performance in mathematics in public secondary schools in Kenya. The data collected using questionnaire from a sample of 248 respondents including head teachers, heads of mathematics departments, mathematics teachers and students, found among other factors students' low entry marks as a cause of poor performance in mathematics in Kenya Certificate in Secondary Education (K.C.S.E). According to them, about 31.3% of the teacher respondents who answered the questionnaires indicated that low entry grade of students contribute to the poor performance in mathematics.

A similar study conducted in Nigeria by Adamu and Sadiq (2014), used same methodology to explore the causes of poor performance in mathematics among public senior secondary school students. They collected questionnaire data from a sample of 361 respondents including 300 students and 61 mathematics teachers in the Azare Metropolis of Bauchi State using disproportionate stratified random sampling technique. The researchers found among other factors that lack of libraries and mathematics laboratories were among some of the factors leading to the poor performance of students in mathematics in the study area. They argued that about 98% of the respondents were of the view that lack of facilities like libraries and mathematics laboratories cause poor performance in mathematics. When asked to suggest ways of improving performance in mathematics, 85% of the respondents were of the view that provision of libraries and mathematical laboratories can help in improving the performance of students in mathematics.

Mtitu (2014) argues that, for effective and efficient teaching, student centered methods that require that teachers put students at the center of their teaching as well as actively involve students in the teaching and learning process must be adopted by teachers. Also, existing literature (Eyyam & Yaratan, 2014; Goos, 2010; Mensah, 2017; Tay & Mensah-Wonkyi, 2018) suggests that when ICT and its tools are integrated into the teaching and learning of mathematics, it has the potential of actively engaging students, thereby making teaching more student centered. In the same vein, ICT integration into teaching and learning of mathematics has the potential of putting students from less endowed schools on the same level as their counterparts in endowed schools to study mathematics (Passey & Rogers, 2004). Thus, with ICT integration as a teaching strategy, students from both categories of schools have the same platform to study mathematics hence there would not be any significant difference in the performance of students from these categories of schools.

The Lancaster report, published by the Lancaster University on a study conducted by Passey and Rogers (2004) identified several equalizing ability of ICT integration into education. The findings of the study suggested among others that ICT places students from different ethnic groups, socio-economic background, those dissatisfied with the traditional method, gender and type of school at the same motivational level to study in Technology Enhance Classroom (TEC). According to them, different categories of students were found to be achieving at different levels from the use of ICT in the classroom. Also, it was found that ICT used in special schools had tremendous effects on the students' communication at a fundamental level. In terms of gender and ethnic background of students, the study found no significant difference in the motivational level between boys and girls or ethnicity of the students in TEC. The authors suggested that to maximize motivational impact of ICT integration, ICT needs to be used in subject specific ways and to be embedded in teaching and learning. The current study explored the ability of ICT integration to provide equal motivation for students from endowed and less endowed schools to study Mathematics as a specific subject at the SHS level.

2.8 Summary of Literature Review

The literature review considered the history of ICT integration in Ghana, then it put the review in context by providing empirical evidence on factors affecting performance in mathematics. These were followed by effect of ICT integration on students' achievement in mathematics, motivational effects of ICT integration and concluded with ICT integration as a tool for bridging the gap between students' achievement in endowed and less endowed schools.

The literature suggests that Ghana has a policy document on ICT integration in education with the responsibility of the ministry of education to see to its implementation at the school level. Thoughout the literature, it was also revealed that ICT integration as a teaching strategy in mathematics education can promote students' motivation in the study of mathematics and improve students' performance in both endowed and less endowed schools. The current study explored the effects of ICT integration in mathematics education in contrast to the traditional instruction on SHS students' achievement and motivation in endowed and less endowed schools.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0. Overview

The study was designed to investigate the effects of integrating ICT in teaching and learning of mathematical concepts in contrast to the traditional method on SHS students' achievement and motivation in endowed and less endowed schools in the Gomoa West district. This chapter presents the research design, population, sample and sampling technique, research instruments and administration of instruments. Other areas covered in this chapter are validity of the instruments, reliability of the instruments, intervention, data collection procedures, data analysis and ethical considerations.

3.1. Research Design

The approach to this study was a combination of both quantitative and qualitative research methods. Hence the study employed a quasi-experimental design using embedded mixed method approach as a strategy of enquiry. Embedded mixed method design is based on the premise that a single data set is not sufficient to answer all the research questions which are different in nature (Creswell, 2012).

The use of the quantitative approach enabled the researcher to use students' test data to ascertain is there was any significant effect of ICT integration on students' achievement in endowed and less endowed SHSs. The quantitative approach also enabled the use of independent and dependent samples t-tests to test for statistical significance in the differences in pre-tests and post-tests scores of participants. The choice of quantitative approach is line with the designs of past studies (Bhagat & Chang, 2015; Eyyam & Yaratan, 2014; Tay & Mensah-Wonkyi, 2018;) which explored the effects of using mathematical softwares on students' academic achievement.

The qualitative approach on the other hand, enabled the use of interview data to get an in-depth understanding of ways in which ICT integration motive SHS students to study mathematics from students' perspective. This approach also facilitated a thorough investigation on how ICT integration motivate SHS students to study mathematics from mathematics teacher's perspective. With the qualitative approach, the researcher was able to collect in-depth views of both students and mathematics teachers on how ICT integration motivate students in mathematics education.

The embedded mixed method design is justified on the basis that the researcher embedded qualitative component within a quantitative design to answer some research questions. According to Creswell (2012), "the purpose of the embedded mixed method design is to collect quantitative and qualitative data simultaneously or sequentially, but to have one form of data play a supportive role to the other form of data" (P. 544). The researcher collected interview data (qualitative) to augment or support the primary data which was test (quantitative). Also quasi-experimental design is justified for the purpose of this study since the study sought to manipulate a variable and measure its effects. The essential feature of quasi-experimental research is that investigators consciously regulate and manipulate the conditions which determine the events in which they are interested, introduce an intervention and measure the difference that it makes (Cohen, Manion, & Morrison, 2007). They further explained that quasi-experimental design is appropriate when experiments are carried out in natural settings or real world rather than the laboratory. The design is also justified on the basis that the experiment was carried out in an educational setting.

3.2. Population

The target population for this study was all SHS 2 students in public SHSs in the Gomoa West district of the central region of Ghana. There are 4 public senior high schools, spread across the length and breadth of the district with a total SHS 2 population of 2056 students for the 2018/2019 academic year. The accessible population was all SHS 2 students in three selected public SHSs in the Gomoa West district with a total population of 1775 students (GES, Gomoa West office, 2018). The population is heterogeneous, consisting of students from various ethnic backgrounds, of which the Gomoa tribe dominate. Three of the public schools are in the remote areas of the district, which are considered to be less endowed, while one is in the district's capital considered to be endowed (Field data, 2018).

3.3. Sample and Sampling Technique

The sample for the study consist of 120 SHS students selected from three public SHSs in the Gomoa West district of the central region. School A is the only endowed school located in the district's capital, while schools B and C are less endowed with similar characteristics. Students are placed in these schools just like in any other SHS in the country through the GES's Computerized School Selection Placement System (CSSPS). Hence students in these schools come from different ethnic and socio-economic backgrounds. Even though students are placed in these schools through the CSSPS, students who select to be placed in schools B and C (less endowed) are mostly from low socio-economic backgrounds while those that select to be placed School A (endowed) are from medium and high socio-economic backgrounds. Hence school A has most of its students from medium socio-economic backgrounds while most of the students in schools B and C are from low socio-economic backgrounds (Field data, 2018). Considering the purpose and the design of the study, the researcher employed both probabilistic and non-probabilistic sampling techniques to select the sample from the population.

Firstly, purposive sampling technique was used to select three public SHSs comprising of two less endowed schools and one endowed school. According to Crossman (2018), purposive sampling is selected based on the characteristics of the population and very useful when a targeted sample needs to be reached quickly. This sampling technique was used because the district has only one endowed school and two less endowed schools which have similar characteristics in terms of academic achievement, population and facilities. Purposive sampling was also used to select the level (SHS 2) because the topic in mathematics that the study investigated is in SHS 2 mathematics syllabus. The SHSs and level were selected, using a purposive sampling because of the special characteristics of the schools and level in facilitating the purpose of the research. Two of the three schools, one endowed and the other less endowed, selected served as the experimental groups. The third school, which is less endowed, served as the control school. To answer the first research question, participants from the less endowed school (school B) of the experimental group and the control group (school C) were used. The participants from the experimental groups (schools A and B) were used in data collection to answer the second and the third research questions. The status of the schools selected and the pairings to answer specific research questions are shown in Tables 1 and 2 respectively.

Table 1. Status and Category of Selected Schools.

School	Status	Category
School A	Endowed	Experimental
School B	Less endowed	Experimental
School C	Less endowed	Control

Table 2. Pairing of Selected Schools to Answer Specific Research Questions.

Research question	Pairing	Status
One	School B and School C	Both less endowed
Two	School A and School B	Endowed and less endowed
Three	School A and School B	One endowed and one less endowed

Systematic random sampling technique was adopted to select the sample participants from each school. According to Descombe (2010), systematic sampling is a random sampling technique where every nth element is selected from the sample depending on the size of the sample relative to the number in the research population. The first nth member to be selected from each class was computed using the formula $\text{nth element} = \frac{\text{Total number in the sample}}{\text{number to be selected}}$. Thus proportionate number of students were selected from each stream of the school to make up the required number. For example to determine the number of students to select from a stream or class of 56 students out of a total number of t students in a school, the formula $\frac{56}{t} \times 40$ was used. The required number was then selected using systematic random sampling procedure as given by Descombe (2010) above. This sampling technique was adopted because of its simplicity, low risk factor and its ability to eliminate clustered selection as supported by (Ross, 2019). The systematic sampling technique enabled the researcher to select samples from each school using their class registers or lists without disrupting the contact hours of students. In all, a total of forty (40) SHS 2 students were selected from each school, making a sample size of one hundred and twenty (120) SHS 2 students.

The samples were selected from the streams in each academic program offered by the schools. School A offers five academic programs; General Arts, Business, General Science, Home Economic and Visual Arts with a total of thirteen (13) streams for SHS 2 (see Table 3). School B also offers five academic programs; General Arts, Business, General Science, Agricultural Science, and Home Economics with a total of 13 streams (see Table 4) while school C offers six academic programs; General Arts, Business, General Science, Agricultural Science, Home Economics and Visual Arts with a total of 12 streams (see Table 5).

Table 3. Samples from Academic Programs and Streams in School A

Program of Study	**Number of Streams**	**Number of Students**	**Number selected**
General Arts	5	272	18
Business	3	126	8
General Science	2	86	6
Home Economics	2	91	6
Visual Arts	1	34	2
Total	**13**	**609**	**40**

Table 4. Samples from Academic Programs and Streams in School B

Program of Study	Number of Streams	Number of Students	Number selected
General Arts	7	291	19
Business	2	112	7
General Science	1	23	2
Home Economics	2	122	8
Agricultural Science	1	60	4
Total	**13**	**608**	**40**

Table 5. Samples from Academic Programs and Streams in School C

Program of Study	Number of Streams	Number of Students	Number selected
General Arts	5	237	16
Business	2	89	6
General Science	1	28	2
Home Economics	2	104	8
Visual Arts	1	49	4
Agricultural Science	1	51	4
Total	**12**	**558**	**40**

Systematic random sampling was employed in selecting the sample to ensure that the sample selected from each school is a representation of the population so that conclusions and findings can be generalized for the entire population.

Simple random sampling technique was finally employed to further select three students from the samples of each of the two experimental schools, making a total of six students, to collect interview data. Also, a total of four mathematics teachers were selected purposively from the two experimental schools to collect interview data. The selection of the mathematics teachers was done based on the teachers available and were willing to participate in the study at the time the interview was conducted.

3.4. Research Instruments

Based on the nature of the research questions examined in the study, Geometry Achievement Test (GAT) and semi-structured interview guide were the instruments used to collect data.

3.4.1. Geometry Achievement Test (GAT)

To gather quantitative data, the researcher used Geometry Achievement Test (GAT) involving Mensuration 1 concept in the SHS mathematics syllabus. Downie (1961) as cited in Rani and Aisha (2017), defined mathematics achievement test as "Any test that measures the attainments or accomplishments of an individual after a period of training or learning" (p. 651). From literature, GAT is widely used in the field of mathematics to measure the attainment of students in many effect studies (Bhagat & Chang, 2015; Tay & Mensah-Wonkyi, 2018; Armah, Cofie & Okpoti, 2017) in geometry. Hence GAT was employed to measure students' attainment in Mensuration I concept before and after treatment.

The GAT was developed by the researcher himself based on the objectives in 2010 SHS core mathematics syllabus, the current syllabus being implemented at the SHS level, on the concept of Mensuration 1. The test instrument was developed by the researcher himself in order to ensure that the items included in the instrument are in the Ghanaian context and also for the test to measure all the objectives on the concept as stated the syllabus. The GAT was in two sections, A and B, containing twenty three (23) items in total (see Appendices A and B). The GAT contained both objective and subjective questions measuring the two profile dimensions; Knowledge and Understanding (KU) and Application of Knowledge (AK) prescribed by the syllabus (see Table 6). KU was given a percentage weight of 30% while AK was given a percentage weight of 70% as suggested by the syllabus. The objective items were essentially intended to test Participants' knowledge and understanding while the subjective items were intended to test participants' application of knowledge in Mensuration I. In all, section A contained twenty (20) multiple choice items while section B contained three (3) subjective questions of greater difficulty measuring all the objectives in the area of Mensuration I (see Table 6). Participants were expected to choose the correct option from the given alternative options lettered A to D in section A and to provide written responses to the items in section B.

Table 6. Structure of GAT pre and post-tests

Objective	**Number of items/profile Dimension**	
	Multiple choice (KU)	**Subjective (AK)**
Find the length of an arc of a circle	2	0
Calculate the perimeter of plane figures.	10	1
Calculate the areas of sectors and segments	6	1
Find the areas of quadrilaterals	2	1
Total	**20**	**3**

3.4.1.1. Structure of GAT pre-test

The GAT pre-test was made up 23 items in total, including 20 objective questions and 3 subjective questions (see Appendix A). Section A contained the objective questions while section B contained the subjective questions. The GAT pre-test was intended to measure participants' level of attainment in the concept before treatment. The GAT pre-test was also to unveil participants' areas of difficulty in the concept in order to design a treatment that would best suit participants' level of attainment.

3.4.1.2. Structure of GAT post-test

The GAT post-test contained the same number of items as the pre-test. However, the items in the GAT post-test were slightly different from those in the pre-test (see Appendix B). The test items measured the same difficulty level of students as the GAT pre-test. According to Creswell (2012), using different test items on pre-test and post-test of a test instrument eliminates biasness from the scores. The post-test was intended to measure participants' attainment in Mensuration I after the treatment has been implemented.

3.4.2. Interview guide

To gather qualitative data, the researcher used interview guide to elicit information. Open-ended semi-structured interview instruments, which outlined the topics to be discussed with participants was employed to solicit responses from participants. According to McLeod (2014), semi-structured interviews (unlike structured) have the advantage of generating qualitative data through the use of open-ended questions which allow the participants have in-depth conversation with the interviewer, choosing their own words. Such interviews have increased validity because it gives the interviewer the opportunity to probe for a deeper understanding, ask for clarification and allow the interviewee to steer the direction of the interview. The researcher therefore used semi-structured interview to seek participants' in-depth views on how the integration of ICT motivate students in learning mensuration I concept. Two semi-structured interview guides, one for student participants and the other for mathematics teachers were developed by the researcher to solicit views on how ICT integration motivate students in learning mensuration from students' and mathematics teachers' perspectives respectively .

3.4.2.1 Structure of students' interview guide

The students' interview guide (SIG) contained six topical items intended to solicit views of students on how ICT integration motivate them in studying mathematics (see Appendix E). The SIG outlined only the major topical areas to ask participants and probes were made when the need arose.

3.4.2.2 Structure of mathematics teachers' interview guide

The mathematics teachers' interview guide (TIG) also contained six topical items intended to solicit views of mathematics teachers on how ICT integration motivate students in studying mathematics (see Appendix F). Just like the SIG, the TIG outlined only the major topical areas to ask participants and follow up questions were asked as and when the need arose. Table 7 summarizes the specific instruments used to collect various data types to answer stated research questions.

Table 7. Classification of Research Instruments According to Research Questions

Research Question	Data source (Subjects/number)	Data collection Tools	Data Type
1. What is the effect of ICT integration on SHS students' achievement in mathematics in contrast to the traditional method?	40 students each from school B (Experimental) and school C (Control)	GAT pre and post-tests	Quantitative
2. To what extent does ICT integration bridge the gap in the achievement of students in endowed and less endowed SHSs	40 students each from school A and school B	GAT pre and post-tests	Quantitative
3. In what ways do ICT integration motivate students to study mathematics at the SHS level?	6 students and 4 teachers from the experimental groups	Interview guide	Qualitative

3.5. Administration and Grading of the GAT

The GAT was administered as pre-test and post-test before and after treatment.

3.5.1. Administration of pre-test

The pre-test was administered in April 2019, three weeks after SHS 2 students resumed for second semester of 2018/2019 academic year. The pre-test was administered immediately after samples were selected and concerns of the selected schools had been received. All participants from the three selected schools took the pre-test in turns on the same day. The test lasted for exactly one hour, after which participant's responses were collected. On the day of the administration, participants from each school were made to sit in a classroom located on the school premises. Participants' sitting arrangement was similar to sitting arrangements in a normal semester examination. Question papers were then distributed to them by the researcher with the instruction not to open until they were told to do so. While waiting to be instructed to start work, participants were asked to read the instructions which were boldly written on the cover page. After about 5 minutes, participants were made to start work under the invigilation by the researcher himself. After one hour, the question papers containing participants' solutions were collected for grading.

The pre-test was administered purposely to help unravel participants' difficulties in Mensuration I so as to plan lessons for both groups, suitable to participants' level of understanding. The pre-test was also to reveal the similarities between the control and the experimental groups before the treatment.

3.5.2 Administration of post-test

The post-test, which contained similar but different items as the pre-test, was administered in June 2019, immediately after the treatment was carried out in all three schools. The post-test was administered in the same semester of the 2018/2019 academic year just as the pre-test. The post test was administered under the same conditions as the pre-test.

3.5.3. Grading of participants' responses

After the GAT pre-test and post-test were administered, students' responses were collected, read and scored by employing adapted WASSCE examining procedures. Each correct response of the 20-items of the multiple choice test was awarded one (1) mark. Hence a student can score between the ranges of 0-20 points. Each written response to the subjective part of the GAT was scored by considering the suitability of formulas and diagrams, appropriateness of the methods employed and the correctness of final answer. An M mark was awarded to methods, a B mark for accuracy not followed by method mark and an A mark for accuracy of the final answer followed by method mark (see Appendices C and D). The subjective part was worth 30 points hence a student can obtain a minimum of zero (0) points and a maximum of thirty (30) points. In total, a participant can score between the ranges of 0 – 50 points in both sections of the GAT.

To ensure that the GAT was appropriately scored and a perfect representation of what the participant had written, the scoring underwent four stages to arrive at the final score for each script. The four stages were adapted from West African Examination Council's procedures of WASSCE marking. To achieve this, the researcher employed the hands of four WAEC experience Assistant Examiners (AE) including himself.

The first stage was the coordination stage. At this stage, all the four examiners met to discuss the marking scheme. After the marking scheme was accepted by all examiners, two of the examiners marked the scripts using the marking scheme. Next, the scripts were sent to the team leader to examine whether the marking scheme was adhered to. Finally, the last examiner checked the scripts to ensure that all scripts were correctly scored and the total marks obtained by each participant was actually what he/she had in the test. The final score for each student was then awarded after all these processes had been exhausted. The researcher then recorded the scores of the participants for analysis.

3.6. Conducting the Interview

To collect qualitative data, interview was conducted using a sample size of ten (10) participants. The ten participants included six students and four mathematics teachers from the experimental schools. Student participants were selected randomly, three from each of the 40 students in the experimental groups who participated in the study while the mathematics teachers were selected purposively from the experimental schools. The interview protocols (Appendices E and F) which contained notes on what will be said before and after the interview, prompts for the collection of informed consent, and prompts to remind the researcher about the topical areas to probe guided the researcher throughout the interview process. According to Jacob and Furgerson (2012), interview protocol is not only a list of interview questions but includes procedural guide for directing the interviewer throughout the interview. To ensure that the interview protocol contained relevant items that would elicit the needed information from participants, it was tested on two students and one teacher from the study population.

After the post-test, the researcher granted one-on-one open ended interviews to participants. Each interview took a minimum duration of 25 minutes and a maximum duration of 40 minutes. According to Jacob and Furgerson (2012) an interviewer must consider the type of people he is interviewing to determine the length of the interview. Since the participants (teachers and students) have busy schedules, the length of the interviews was designed within 25 – 40 minutes. The researcher used a total of two days to conduct the interviews, interviewing participants in the first experimental school on the first day and those in the other school on the second day. The researcher audiotaped the questions and responses of the interviews and also took brief notes at the same time to serve as backup. Students' and teachers' interview guides (see Appendixes E and F) containing the topical questions to be asked were strictly followed but probes were done when there was the need to obtain additional information.

3.7. Validity of the Instruments

According to Creswell (2012), the validity of an instrument is the degree to which an instrument measures what it is intended to measure. To ensure the validity of the GAT, the SHS mathematics syllabus and approved textbooks by the Ghana Education Service (GES) were consulted in the test construction. Also, WAEC past questions on mensuration 1 were consulted. This was followed by consulting researcher's supervisor and colleague MPhil. Mathematics Education students ensure content validity. According to Dzakadzie (2017), content-related validity is important because it takes care of the requirements of the teaching curriculum, domain of importance and what people think should be taught and assessed.

Furthermore, the GAT was piloted on 20 students selected from a similar school in the district mainly to detect lack of clarity in the phrasing of the questions, and to give indication for the appropriateness of time needed for its completion. The answered test items were scored using the rubrics to help refine the instrument. The topical questions in the interview guide were also cross checked by the researcher's supervisor and corrections and inputs made to ensure its content validity.

3.8. Reliability of the Instruments

Reliability is the degree of consistency of an instrument. That is reliability is the degree to which assessment results will be same when administered on different occasions (Creswell, 2012). The reliability of an instrument can be checked in several ways. In this study, the researcher employed test-retest approach to examine the reliability of the GAT. According to Creswell (2012), the test-retest approach of measuring reliability involves administering the same instrument at two different times to the same participants at a sufficient time interval. Also, there are two necessary conditions in test – retest reliability. The first is that the true score does not change between administrations and the second one refers to the time period being long enough to prevent learning, carry over effects or recall. Using this approach, the researcher administered the GAT to an intact SHS 2 class of 42 students in one of the selected schools and after a month re-administered the GAT to the same class again. Participants' responses for both administrations of the GAT were scored and correlated using Pearson correlation coefficient (r) used in reliability testing in SPSS. One disadvantage of using Pearson correlation coefficient is that it overestimates the true relationship between the two test results for small sample size below 15 (Glen, 2016). This was compensated for by using a sample size of 42 students. The value of r was 0.868 which indicates a good degree of reliability of the GAT. This approach was employed because it has the advantage of requiring only one form of the instrument especially when the instrument was developed by the researcher himself.

3.9. Treatment

The purpose of the study was to measure the effects of ICT integration on students' achievement in mathematics and motivation to learn mathematics as compared to the traditional way of teaching mathematics in endowed and less endowed SHSs. To this end, the treatment process was designed in pursuant to the achievement of this purpose.

The treatment took a total of four (4) weeks. During these 4 weeks, both the experimental and control groups were taken through lessons involving Mensuration 1 concept. The traditional method to teaching, where marker board and textbooks are used by the teacher in the teaching process, was applied to the control group while ICT integration approach was applied to the experimental groups. The experimental and the control groups were both taught during the treatment period. The only difference between the teaching strategies was that ICT was integrated into the teaching and learning process of the experimental group while the traditional method of teaching mathematics was applied to the control group. The lesson for the experimental group (see Appendix H) was designed in accordance with fundamental principles of the Engagement Theory (ET) which articulates that students/pupils build their own understanding and knowledge of the world and concepts through experiencing things and reflecting on those experiences in an environment provided by technology integration. The ET also stipulates that technology can facilitate students' engagement in many ways which are difficult to achieve using other approaches. That is, the lessons taught in the experimental group were implemented with a method in which ICT integration approach emphasizing on students own experiences of the learning process for understanding of concepts were implemented.

Participants in each school were met twice in a week for a duration of ninety (90) minutes per meeting. The meeting schedules for the treatment (see Table 8) were arranged before and after normal school contact hours in order not to disrupt the time table of the schools. After the treatment, participants were informed about the post-test scheduled for the following day.

Table 8. Time table for treatment

Days → School ↓	Monday	Tuesday	Wednesday	Thursday	Friday
A	lesson 3:00 – 4:30pm	-	-	lesson 3:00 – 4:30pm	Group work 3:30 – 4:30pm
B	-	lesson 6:00 – 7:30am	-	lesson 6:00 – 7:30am	Group work 3:30 – 4:30pm
C	-	lesson 3:30 – 5:00pm	lesson 3:30 – 5:00pm	-	Group work 3:30 – 4:30pm

3.10. Data Collection Procedure

The researcher visited the 3 selected SHSs with Letters of introduction, obtained from the Head of Mathematics Department of University of Education, Winneba (see Appendix I), in the early part of the second semester of 2018/2019 academic year and made his intentions known to the schools' administrations. The researcher met the Heads of these SHSs and briefed them on the purpose of the study and asked for their permission to use their students in the study. The heads later gave their permission and introduced the researcher to their assistant headmasters in charge of academics. The assistant heads then introduced the researcher to the heads of the Science departments, where mathematics department is a unit, of the various schools for further action. After going through all the necessary procedures a date was scheduled for another visit to select the samples and schedule a date for the pre-test. On the appointed day, the researcher went to each school and selected the samples using the class registers/list provided to him by assistant headmasters in charge of academic. The selected students were given consent forms (see Appendix H) to sign in order to agree to participate in the study. After all the participants had signed the consent forms and returned same, the researcher administered the pre-test (the GAT) to them during the third week of the second semester of the 2018/2019 academic year.

After a four week treatment, the post-test (which was similar to the pre-test) was administered to participants. The researcher then granted one-on-one interviews to 6 students and 4 mathematics teachers selected from the experimental groups to seek for their in-depth views on how ICT integration in mathematics education motivates students to learn mathematics specifically, the Mensuration 1 concept. Interview data were collected from all participants by the researcher himself by applying the same procedures to each person and following strictly the procedures provided on the interview protocol in order to avoid any biasness in the data. The questions and responses from the one-on-one interviews were audiotaped to give an accurate record of the conversation. After both test and interview data has been collected, the researcher thanked the participants for their time and told them of a possibility of a subsequent contact if there is a need for him to clarify information or ask additional questions. The schools' administrations were also thanked for the opportunity granted to the researcher.

3.9. Data Analysis

This section of the study describes the variables that were used in the data analysis and as well states the statistical procedures that were used to test the hypotheses. The variables in the study include two independent variables (teaching strategies – ICT integration versus Traditional method) and two dependent variables (students' achievement and motivation). The study used the embedded mixed method approach which employed quasi-experimental design as a strategy of enquiry. Data collected involved both quantitative and qualitative data and in order to answer the stated research questions (RQ), data collected were analyzed using the Statistical Package for Social Sciences (SPSS) version 21.0

Quantitative data collected from the scores of the GAT were analyzed by employing both descriptive and inferential statistics. Descriptive statistics such as frequency tables, measures of central tendencies and measures of dispersion were employed. According to Creswell (2012), descriptive statistics basically helps researchers to summarize the overall trends or tendencies in quantitative data, provides an understanding of the variability of the data and provides understanding of how one score compares with another. Thus descriptive statistical analysis was used in an attempt to understand, interpret and describe the scores of experimental and control groups from the GAT. Pie charts were also used to give pictorial interpretation of the results.

For inferential statistics, Independent samples t-test and paired samples t-test were run to compare for any significant difference in the scores of the experimental and control groups at 95% confidence level. Specifically, to determine whether ICT can bridge the gap between the performances of students in endowed and less endowed schools (RQ.2), an independent samples t-test statistical procedure at 95% confidence interval was performed to compare for any significant difference in the means of post-tests of the two experimental groups. Independent samples t-test was also performed at 95% confidence interval to compare for any significant difference between teaching strategy and the achievement in mathematics of participants (RQ.1). Furthermore, dependent samples t-test was performed to compare pre-test and post-test scores of each group.

Qualitative data was generated from interviews to answer RQ.3. A qualitative interview occurs when researchers ask open-ended questions to one or more people, record the conversation and later transcribe and input it into a computer program for analysis (Creswell, 2012). Recorded data generated from the one-on-one interviews were analyzed using thematic analysis. That is recorded audio from the interviews granted to participants were transcribed and analyzed based on the topical areas contained in the interview guides. The researcher reported all events that emanated from the interviews by describing and interpreting the outcomes after reading the transcribed interviews.

3.11. Ethical Considerations

Ethics are the norms or standards for conduct that distinguish between right and wrong and help to determine the difference between acceptable and unacceptable behaviors on the part of the researcher. Ethical consideration is very important in research as the integrity, reliability and validity of the research findings rely heavily on adherence to the ethical principles underlying the research (Creswell, 2012).

One of the instruments used in this research were interviews. As recordings of students' natural conversations was involved, informed consent was obtained for this purpose. Both oral and written explanation of the study was given to the participants before the recording. The researcher also ensured that consent forms (see Appendix G) were signed by the participants involved to allow the researcher to use the data.

Furthermore, Issues relating to voluntary participation was adhered to as participants were made aware of their right to participate on their own free will and withdraw from the study at any time. Confidentiality and anonymity of the subjects were also adhered to as information between participants and the researcher were kept confidential. Also, students were not made to write their names on the instruments as a way of ensuring confidentiality of data.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0. Overview

The study sought to use both quantitative and qualitative data to measure the effects of ICT integration on students' achievement and motivation in the study of mathematics in endowed and less endowed SHSs. The chapter begins with the presentation of demographic information of study participants. This is followed by the results of the study which were presented in three sections based on the research questions that guided the study. The chapter concluded with the discussions of the results.

4.1. Demographic Information of Participants

The total population of SHS 2 students in the three selected schools for the 2018/2019 academic was 1,775 students, out of which 775 were males and 1000 were females (GES, Gomoa West district, 2019). The population distribution, gender, residential status of students and locations of the selected schools are shown in Table 9.

Table 9. Population distribution of SHS 2 students in selected schools

School	Total	Male (%)	Female (%)	Boarding (%)	Day (%)	Location
A	609	249 (41%)	360 (59%)	609 (100%)	0	Apam
B	608	280 (46.1%)	328 (54.9%)	328 (53.9%)	280 (46.1%)	Gomoa Eshiem
C	558	246 (44.1%)	312 (55.9%)	337 (60.4%)	221 (39.6%)	Dawurampong
Total	**1775**	**775 (43.7%)**	**1000 (56.3%)**	**1274 (71.8%)**	**501 (28.2%)**	-

From Table 9, it would be realized that majority of the SHS2 students in the district for the 2018/2019 academic year were females (56.3%). This depicts the general gender characteristics of the total number of students in the district for 2018/2019 academic year. Also, it would be realized that majority of the students from schools B and C (46.1% and 39.6% respectively) were day students as compared to school A, where all students were boarders. This buttresses the findings of many researchers (Adamu & Sadiq, 2014; Gegbe & Sheriff, 2015, Gitaari & Nyaga, 2013) that less endowed schools lack basic facilities such as dormitories as compared to endowed schools.

Table 10 shows the demographic information of the 120 selected SHS 2 students who participated in the study including their gender, residential status and socio-economic status.

Table 10. Demographic information of selected students in Gomoa West District.

School	Total selected	Male (%)	Female (%)	Boarding (%)	Day (%)	Socio-economic status
A	40	17 **(42.5%)**	23 **(57.5)**	40 (100%)	0	medium
B	40	19 **(47.5%)**	21 **(52.5%)**	29 (72.5%)	11 (27.5%)	low
C	40	16 (40%)	24 (60%)	24 (60%)	16 (40%)	low
Total	**120**	**52 (43.3%)**	**68 (56.7%)**	**93 (77.5%)**	**27 (22.5%)**	

From Table 10, it would be realized that the selected students possess common characteristics as the entire population as shown in Table 9 above. Characteristics such as gender and residential status of the participants reflected the actual situation of the entire schools that participated in the study. Also, from Table 10, it would be realized that about 40% and 27.5% of participants from schools B and C respectively (the less endowed schools) were day students as compared to 0% day students in school A (the endowed school). Also, most of the participants from schools B and C come from low socio-economic backgrounds as compared to those in school A.

Furthermore, it was found that schools B and C have no accommodation for no teaching staff on campus while school A has accommodation for more than 50% teaching staff on campus. This further supports the claim by (Adamu & Sadiq, 2014; Gegbe & Sheriff, 2015, Gitaari & Nyaga, 2013) that less endowed schools lack facilities that facilitate teaching and learning. However, the characteristics of Mathematics teachers in the three selected schools were similar. Students in all the three selected schools were taught by Mathematics teachers whose minimum qualification was Bachelor's degree in Mathematics. Majority of the instructional staff had their degrees with educational component.

4.2. Geometric Achievement Test (GAT) Results

This section presents, the results of the Geometric Achievement Test (GAT) administered to student participants. All the 40 participants from all three schools that were selected and agreed to participate in the study participated in both the pre-test and the post-test of the GAT. The results from both tests are presented in this section.

4.3. The GAT Pre-test Results for Experimental and Control groups.

The pre-test scores were analyzed based on the pairings shown in Table 11 below in order to answer the stated research questions (RQ). The results of the pre-test are presented in this section.

Table 11. Pairing of Selected Schools to Answer Specific Research Questions.

Research question	Pairing	Status
One	School B and School C	Both less endowed
Two	School A and School B	Endowed and less endowed
Three	School A and School B	One endowed and one less endowed

4.3.1. Comparison of pre-test scores of control and experimental groups (Schools B and C)

The pre-test scores of experimental and control groups were compared to determine if there exist any significant difference in the scores before treatment. In general, the pre-test results revealed no significant difference between the experimental and control groups involving the two less endowed schools (schools B and C). Table 12 illustrates the mean, standard deviation, maximum and minimum of the pre-test scores between the experimental group (School B) and the control group (School C).

Table 12. Descriptive Statistics of Pre-test Scores of Experimental and Control Groups

Group	N	Mean	Stand Dev.	Maximum	Minimum
Experimental (B)	40	13.83	6.77	27.00	4.00
Control (C)	40	13.38	7.25	24.00	3.00

From Table 12, the results showed a mean score of 13.83 and 13.38 for the experimental and control groups respectively. The minimum score of the experimental group was 4 while that of the control group was 3. Also the experimental and control groups scored a maximum mark of 27 and 25 respectively. Comparing the mean scores of the groups would suggest that the experimental group performed better $(mean = 13.83)$ than the control group $(mean = 13.38)$. To test whether the difference in mean scores between the experimental and control groups was statistically significant, independent samples t-test was performed at 95% confidence interval. The results of this test is illustrated in Table 13.

Table 13. Independent Samples T-test of Pre-test of Experimental and Control Groups

Groups	N	Mean	Std. Dev.	t-value	df	p-value
Experimental (B)	40	13.83	6.77	0.287	78	0.775
Control (C)	40	13.38	7.25			

The results from the independent samples t-test (Table 13) performed on the pre-test scores of the two independent groups (i.e. experimental and control groups) revealed that there was no statistically significant difference between the experimental group $(M = 13.83,\ SD = 6.77)$ and control group $(M = 13.38,\ SD = 7.25)$ conditions; $t\ (78) = 0.287, p = 0.775 > 0.05$. This result suggests that both the experimental and control groups were at the same level in terms of conceptual understanding of the concept of mensuration (perimeter and area of plane figures) before intervention was carried out.

4.3.2 Comparison of pre-test scores of endowed and less endowed experimental groups (Schools A and B)

The pre-test scores of school A (endowed) and school B (less endowed) were compared to determine if there was any statistically significant difference between their scores in the pre-test. The results indicated a mean score of 23.03 for the endowed school (school A) and 13.83 for the less endowed school (school B). Also, school A obtained a maximum and minimum score of 30 and 10 respectively as against 27 and 4 respectively for school B (see Table 14).

Table 14. Descriptive Statistics of Pre-test scores of School A (Endowed) and School B (Less Endowed)

Group	N	Mean	Stand Dev.	Maximum	Minimum
Endowed (A)	40	23.03	5.36	30.00	10.00
Less Endowed (B)	40	13.83	6.77	27.00	4.00

The result from Table 14 showed a mean score of 23.03 for the endowed school as compared to a mean score of 13.83 for the less endowed school. The results indicated a difference between the mean scores of schools A and B with respect to performance in the pre-test. To ascertain whether the difference between the mean scores was statistically significant, independent samples t-test was performed at 95% confidence level. The results of the independence samples t-test performed on the pre-test scores of schools A and B is illustrated in Table 15.

Table 15. Independent Samples t-test Comparing Pre-test Scores of Endowed and Less Endowed Groups

Groups	N	Mean	Std. Dev.	t-value	df	p-value
Endowed (A)	40	23.03	5.36	6.737	78	0.000
Less Endowed (B)	40	13.83	6.77			

The results from the independent samples t-test (Table 15) performed on the pre-test scores of the two independent groups (i.e. endowed and less endowed groups) revealed that there was statistically significant difference between the endowed school $(M = 23.03,\ SD = 5.36)$ and control group $(M = 13.83,\ SD = 6.77)$ conditions; $t\ (78) = 6.737, p = 0.000 < 0.05$. These results suggest that the groups (i.e. endowed and less endowed) were not at the same level in terms of achievement in mensuration (perimeter and area of plane figures) before intervention was carried out.

4.4. The GAT Post-test Results for Experimental and Control Groups.

After the treatment, a post-test was administered to all groups to measure the level of change in achievement as compared to the pre-test. This section presents the results from the post-test scores for the three groups involved in the study.

4.4.1. Comparison of pre-test and post-test scores of schools A, B and C.

The pre-test and post-test scores within groups were compared to establish if there was an improvement in understanding of participants in mensuration concept in the post-test. This comparison was done for all three schools and the results are presented in Tables 16, 17 and 18.

4.4.1.1 Comparison of pre-test and post-test scores of schools A

Table 16 illustrates the mean, standard deviation, maximum and minimum scores of the pre-test and post-test sores of school A. The results revealed a maximum score of 45 in the post-test compared to a maximum score of 30 in the pre-test. Also, the results indicated a mean score of 31.28 in the post-test against 23.03 in the pre-test.

Table 16. Descriptive Statistics of Pre-test and Post-test Scores of School A.

Test	N	Mean	Stand Dev.	Maximum	Minimum
Pre-test	40	23.03	5.36	30.00	10.00
Post-test	40	31.28	8.25	45.00	15.00

The results from Table 16 suggest an improvement in the post-test scores. The maximum score improved from 30 to 45 while the minimum score improved from 10 to 15. This is an indication that the performance of every participant improved after the intervention. To get a pictorial representation of the difference between the achievements of school A in the pre-test and post-test, the result is illustrated on a pie chart as shown in Figure 1.

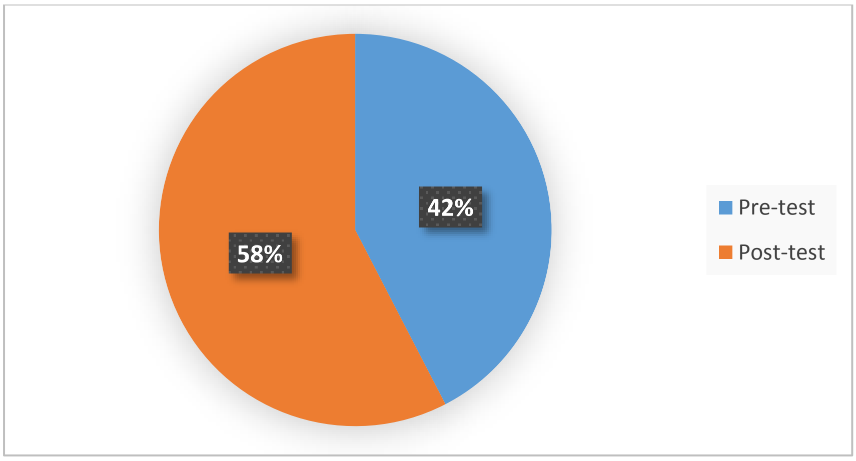


Figure 1. A Pie Chart Showing the Means of Pre-test and Post-test Scores of School A

As indicated in Figure 1, there was improvement in the mean scores of the post-test (58%) as compared to the pre-test (42%). This is an indication that in the post-test, the performance of every participant has increased in the experimental group. The improvement in the post-test scores might be due to the integration of ICT into the instruction process

4.4.1.2. Comparison of pre-test and post-test scores of school B

Table 17 illustrates the mean, standard deviation, maximum and minimum scores of the pre-test and post-test sores of school B. The results revealed a maximum and minimum scores of 40 in and 10 respectively in the post-test compared to 27 and 4 respectively in the pre-test.

Table 17. Descriptive Statistics of Pre-test and Post-test Scores of School B

Test	N	Mean	Stand Dev.	Maximum	Minimum
Pre-test	40	13.83	6.77	27.00	4.00
Post-test	40	23.70	8.47	40.00	10.00

From Table 17, it would be realized that there was an improvement in the mean scores between the pre-test (13.83) and the post-test (23.70). Figure 2 further illustrates this improvement in terms of percentages on a pie chart.

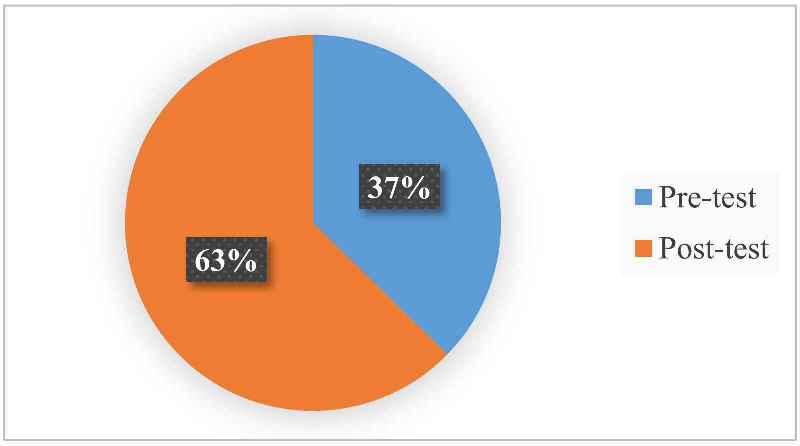


Figure 2. A Pie Chart Showing the Means of Pre-test and Post-test Scores of School B

As indicated in Figure 2, there was an improvement in the mean scores of the post-test (63%) as compared to the pre-test (37%). These results suggested over 25% difference in the achievement between the pre-test and post-test. These improvement might be due to ICT integration in the instruction process.

4.4.1.3. Comparison of pre-test and post-test scores of school C

Table 18 illustrates the mean, standard deviation, maximum and minimum scores of the pre-test and post-test sores of school C. The results revealed a maximum and minimum scores of 33 and 5 respectively in the post-test compared to 24 and 3 respectively in the pre-test. Also, the results indicated a mean score of 18.50 in the post-test compared to a mean score of 13.38 in the pre-test.

Table 18. Descriptive Statistics of Pre-test and Post-test Scores of School C.

Test	N	Mean	Stand Dev.	Maximum	Minimum
Pre-test	40	13.38	7.25	24.00	3.00
Post-test	40	18.50	7.63	33.00	5.00

From Table 18, the mean score in the pre-test increase from 13.38 to 18.50 in the post-test. This suggests an improvement in the performance of participants in school C who went through the traditional interaction. Figure 3 gives a pictorial representation of the results in terms of percentages.

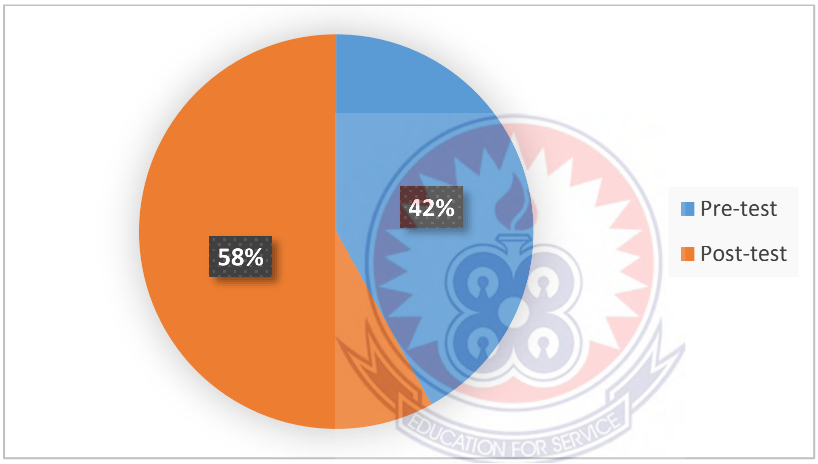


Figure 3. A Pie Chart Showing the Means of Pre-test and Post-test Scores of School C

From Figure 3, it would be realized that there was an improvement in the post-test scores (58%) compared to the pre-test score (42%).

To establish whether the difference in the pre-test and post-test scores of each group (School A, B and C) was statistically significant, paired samples t-test was conducted to compare the pre-test and post-test scores. The results from the paired samples t-test of participants from all three groups are illustrated in Table 19.

Table 19. Paired Sample T-tests of Pre-and Post-tests of the Three Groups

	N	Mean Difference	Std. Dev.	Std. Error Mean	t-value	df	p-value	Eta Squared
Pre-test – Post-test (School A)	40	8.250	3.418	0.540	-15.268	39	0.000	0.265
Pre-test – Post-test (School B)	40	9.875	2.065	0.327	-30.238	39	0.000	0.298
Pre-test – Post-test (School C)	40	5.125	1.652	0.261	-19.626	39	0.000	0.108

The results of the paired samples t-test (Table 19) of participants from school A (endowed experimental group), who were taught using ICT integrated lessons, indicated that there was statistically significant difference in their mean scores from the pre-test to the post-test, conditions; $t(39) = -15.268, p = 0.000 < 0.05$. The eta squared value of 0.265 shows a large effect size between the two scores. This value showed that 26.5% of the variance of the post-test score of participants was accounted for by the teaching method (ICT integration). According to , the Cohen's rules of thumb on magnitudes of eta squared interpretation given by Miles and Shelvin (2001), an eta squared value of 0.01 (1%) has small effect size while eta squared values of 0.06 (6%) and 0.14 (14%) have medium and large effect sizes respectively. This result indicates that the extent of the difference between the mean scores on the pre-test and the post-test of the students in school A (endowed) taught with the ICT integration was large.

Also, the results of the paired samples t-test (Table 19) of participants from school B (less endowed experimental group), who were also taught using ICT integrated lessons, indicated that there was statistically significant difference in their mean scores from the pre-test to the post-test, conditions; $t(39) = -30.238, p = 0.000 < 0.05$. Again, the eta squared value of 0.298 showed a large effect size indicating that 29.8% of the variance of the post-test scores were improved by integration of ICT at the intervention stage. By this eta squared value, it implies that difference in achievement between the mean scores of the pre-test and post-test scores of school B (less endowed), where ICT was used was also large. However, the effect of ICT integration on the achievement of students in the less endowed school (school B) was larger than that of the endowed school (school A) as depicted by the eta squared values.

Finally, the results of the paired samples t-test (Table 19) of participants from school C (control group), who were taught using the traditional teaching method, also showed that there was statistically significant difference in their mean scores from the pre-test to the post-test, conditions; $t(39) = -19.626, p = 0.000 < 0.05$. This might be due to the well-structured traditional approach employed in the teaching of the control group. The eta squared value of 0.108 here, showed a medium effect size between the pre-test and post-test scores of the group where ICT was not integrated into their lessons. This result indicates that if traditional method is carried out effectively, it may improve students' achievement in mathematics but not as much as when ICT integration method is used.

4.5. Research Question 1: What is the Effect of ICT Integration on SHS Students' Achievement in Mathematics in Contrast to the Traditional Method?

Research question one focused basically on the effectiveness of ICT integration in teaching and learning the concept of mensuration in contrast to the traditional instruction on students' achievement. To find answers to this research question, the following hypothesis was formulated for the study;

Hypothesis: There is no difference between ICT integration and traditional instructional methods of teaching on SHS students' achievement in mathematics.

To test the hypothesis, independent samples t-test was conducted to establish if there was statistically significant difference in the post-test scores between the group taught with ICT (school B – experimental) and the group taught with the traditional method (school C - control). The independent variable for the test was the teaching method (i.e. ICT integration or the traditional method) and the dependent variable was the achievement in the post-test of the two groups. The results of the independent samples t-test is illustrated in Table 20.

Table 20. Independent Samples t-test of Post-test Scores of the Experimental and Control Groups

Groups	N	Mean	Std. Dev.	t-value	df	p-value	Eta Squared
Experimental (B)	40	23.70	8.47	2.885	78	0.005	0.096
Control (C)	40	18.50	7.63				

From Table 20, the results of the independent samples t-test revealed that there was statistically significant difference between the experimental group $(M = 23.70,\ SD = 8.47)$ and control group $(M = 18.50,\ SD = 7.63)$ conditions; $t\,(78) = 2.888, p = 0.005 < 0.05$. This result suggests that the experimental group which was taught with ICT outperformed the control group taught with the traditional method. The effect size (eta squared value) was calculated and was found to be 0.096. This eta squared value indicates a medium effect size which implies that 9.6% of the variance in the post-test scores of the GAT (dependent variable) is elucidated by the teaching method (independent variable). This result indicates that the extent of the difference between the mean score achievement on the post-test of the students taught with the ICT integration approach and those taught with the traditional approach was medium.

4.6. 2. To what extent does ICT integration bridge the gap in the achievement of students in endowed and less endowed SHSs?

Research question 2 essentially investigated the extent to which ICT integration in teaching and learning of mathematics could bridge the gap in achievement levels of students in endowed and less endowed SHSs. In answering this question, the endowed (School A) and the less endowed (school B) schools were both instructed by integrating ICT in the teaching and learning process. The hypothesis below was formulated in order to find answers to this RQ;

Hypothesis: There is no significant difference between the academic achievements of students from endowed and less endowed schools when ICT is integrated in teaching mathematics

To test the hypothesis, independent samples t-test was performed on the post-test scores of these two experimental groups (One endowed and one less endowed) to ascertain whether there was statistically significant difference in the mean scores of the post-test between them. The result is illustrated in Table 21

Table 21. Independent Samples t-test of Post-test Scores of both Experimental Schools.

Groups	N	Mean	Std. Dev.	t-value	df	p-value	Eta Squared
Endowed School (A)	40	31.28	8.25	4.052	78	0.000	0.174
Less Endowed School (B)	40	23.70	8.47				

The independent samples t-test (Table 21) conducted revealed that there was statistically significant difference between the mean scores of the endowed group $(M = 31.28,\ SD = 8.25)$ and the less endowed group $(M = 23.70,\ SD = 8.47)$ conditions; $t(78) = 4.052, p = 0.000 < 0.05$. This result suggests that the participants from the endowed group outperformed their counterparts from the less endowed school, who were both taught using ICT, on the post-test. The eta squared value of 0.174 (17.4%) indicates a large effect size which implies that 17.4% of the variance in the post-test scores of the GAT (dependent variable) was accounted for by whether the school is endowed or less endowed (independent variables). The result implies that even though ICT integration in teaching mathematics led to improvement in the academic achievement of SHS students in both endowed and less endowed schools, the difference in the achievement level between these schools was still large. In other words, ICT integration could not bridge the gap in the achievement levels between students in endowed school and those in less endowed schools.

4.7. Research Question 3: In What Ways do Integration of ICT Motivate Students at the SHS Level to Study Mathematics?

Research question 3 sought to find out ways in which ICT integration in the teaching and learning of mathematics motivate students to study mathematics. In answering this research question, semi-structured interviews were granted to six students selected randomly from the sample taught using ICT integration approach during treatment and four mathematics teachers selected purposively from the two experimental schools. To ensure anonymity of information provided by the interviewees, the six student participants were given the codes; S01, S02, S03, S04, S05 and S06 while the teacher participants were given the codes; T01, T02, T03 and T04. The interview data was analyzed according to the themes contained in the interview guide. The analysis of the interview data is presented in this section.

Students' interviews were analyzed based on the Topical Questions contained in students' semi-structured interview guide used to collect interview data from them. To elicit students' views on what they think about Mathematics as a subject in the curriculum, this was what S01 said when the question was thrown to him:

> *Whenever we have mathematics some students run out of class because of how our mathematics teacher teaches. Sometimes, the teacher rushes through topics assuming that we have been taught at the junior high level and this makes the subject difficult for us to learn.*

When probed further, he said, "*So, mathematics is a difficult subject and we don't like studying it*". When S03 was asked the same question, she smiled and remarked, "*with regards to core mathematics when the teacher comes to class, he just sit down and give us the concept and then some examples to solve so I find it difficult learning the subject*". Continuing she said: "*to me, Mathematics is the most difficult subject among all the subjects we do here. From JHS time I find it difficult to understand mathematics topics and every term I pass all the subjects except maths*".

S06 in his response to the same question said that "*All I can say is that Mathematics is not easy at all and I don't see it being used in anything*". From the responses, the participants were of the view that mathematics is one of the difficult subjects in the curriculum if not the most difficult. This according to most of them is due to the abstract nature of mathematics and the teaching methods adopted by most mathematics teachers in teaching the subjects. This finding points to the existing situation in Ghanaian classrooms where students are not comfortable with the subject. It was also clear from the interview that most students lack interest in the subject to the extent of leaving the class when it's time for mathematics lessons. This finding is consistent with the findings of many studies (Gegbe et al., 2015; Mbugua et al. 2012; Sa'ad et at., 2014) which investigated the causes of poor performance in mathematics.

To enquire from participants how they were taught mathematics by their teachers, the question: How does your mathematics teacher teach mathematics mostly in your class and does this method make you want to learn mathematics always? was asked. With regards to this question, all the participants said their mathematics teachers use the traditional approach in teaching them. That is teachers come to class and explain concepts to them using chalk/marker board illustrations and then give them some examples from textbooks to solve. This method according to them, does not motivate them to study mathematics. When asked the question, S02 observed that:

> *When my maths teacher comes to the class, he writes the topic on the board and then explain it to us at the same time giving us notes to copy. We then solve some examples he takes from his textbook and then we do some exercises for him to mark.*

When she was asked whether her teacher's method motivates her to study mathematics, she breathed hard and said, *mostly it is boring when the teacher is writing on the board and dictating plenty notes for you to write. This method does not motivate me to learn*. Responding to the same question, S04 remarked:

> *First he will explain the concept to us then go to the board and solve examples with us and then give us some questions to try on our own. This method most times does not motivate me to learn mathematics.*

The responses suggest that mathematics teachers widely use the traditional approach in their instruction. This finding is in line with the findings of Sa'ad et al., (2014) that most mathematics teachers in the WASSCE sub-region use the traditional approach in teaching mathematics in the classroom.

When S05 was asked whether her mathematics teacher has ever employed ICT in teaching her mathematics in her entire school period, she shook he head and lamented that *no! From Kindergarten up to now no maths teacher has ever used ICT to teach me*. When I asked her why she thinks her teacher doesn't integrate ICT in his teaching, remarked:

> *Maybe the school is not having enough ICT lab to help him teach. Also I think the duration of mathematics on the time table is not enough to walk from our classrooms to the lab and still have enough time to learn.*

S06 in his response to the same question, was of the view that his mathematics teacher is not having fair knowledge of how to integrate ICT into the teaching of mathematics. Saying, *no, I have never been taught mathematics with ICT. First of all, our ICT lab is very small and also I don't think my mathematics teacher has that fair knowledge about using computer*. The responses to this question revealed that none of the students interviewed have been taught with ICT integration approach in their entire education period. According to all participants interviewed, their first time of learning mathematics with ICT integration was during the treatment stage of this research study. When probed further on why they think their teachers do not integrate ICT into the teaching process in their current school, most of them were of the view that it might be due to the existence of only one ICT laboratory on campus. This finding is in line with the study by Agyemang & Mereku, (2015) who found that most Ghanaian mathematics teachers do not integrate ICT into their teaching and learning process.

The question, what difference did ICT integration make in your learning process as compared to your teachers' method? was next asked to elicit students' views on how different ICT integration approach was compared to their teachers' instructional approach. With regards to this question, participants were of the view that ICT integration had a tremendous impact on their learning process as compared to the traditional method employed by their teachers. When probed further on how ICT integration made learning different, most of them were of the view that, the projection of diagrams and real-life images of the concepts, the animations and other features provided by the PowerPoint presentation, made the lesson so practical to the extent that they felt mathematics was just around them. S03 remarked that, "*when I see something projected I am able to remember as compared to you telling me what it is. So looking at the picture I am able to get it rather than you telling me".* Most of the participants were also of the view that using ICT is fun and kills boredom since it is practical. S01 in his response said:

> *Using ICT is fun because we don't write plenty notes and always most of the concepts are practical and we are watching as if we are watching movie so it's easy for you to understand than to write notes and after that you have to go and sit down and study it again*"

From the participants' responses, they were of the view that ICT integration makes the teaching of most mathematics concepts more practical than the traditional method of teaching those concepts. These findings agree with the study conducted by Wong and Wong, (2017) which found that the integration of ICT makes teaching concepts more practical in technological enhanced environment.

To obtain participants' views on how ICT integration motivated them to study mathematics, the question: Were you motivated to study mathematics with this method of teaching (ICT integration)? How?, was asked. The responses of all the participants indicated that they were motivated by the ICT integration approach in teaching mathematics. When asked how they were motivated by this method of teaching, S01 recalled his own experiences learning mathematics during the treatment stage saying, t*his is what I just said that during preps I learn core mathematics. Previously [it's very very] rare, I don't learn it but now I learn it*. When asked how ICT integration motivated him, he sat in an upright position and said:

> *The lessons we had with you were so practical that even if you are sleeping and someone call you from your sleep and ask you a question on what we have done you can recall easily. The way the images were displayed … for example when you were teaching us perimeter, [you can see a student going round the field] to show that perimeter is the total distance around a shape.*

When S02 was asked the same question, he responded:

> B*ecause, I think whenever we are having lesson with you, I'm happy because everything that we are going to study I'm not going to write all that [plenty notes] because I am going to watch the lesson as if I am watching movie so after class I can choose to just solve some past questions or move on to learn other subjects [so that one is good]*.

When probed further, she remarked that, *I learn a lot from watching and practicals than reading notes and your teaching with ICT is helping me to achieve that.* S05 in his answer to the same question remarked that ICT integration has helped increase the time he allotted to the study of mathematics. He responded:

> *ICT has motivated me because I understand [when using the ICT to teach core math] I understand better than the teacher coming to the class [to come and teach]. Also when you started teaching us with ICT I learn core maths three times in a week but first I only learn core maths when we are going to write a test or examination.*

These responses suggested that the students were motivated to study mathematics because of the practicality that ICT integration promotes. As remarked by some of them, the practicality has led to improvement in their study times. Also, the participants were of the view that ICT takes away boredom and makes the lesson interesting by providing an atmosphere compared to that of a movie show.

When S02 was asked if he is taught with this method throughout the rest of his time in school, he would be motivated to study mathematics and why, he sat comfortably and with a smile he responded:

> *Yes it will help [papa] because when we were learning perimeter how you were using pictures is like watching a movie and when you watch movie it sticks in your brain and it will take long time before you will forget what you have watched.*

This was the response of S01 when he was asked the same question:

> *[Ooh yes] I will like it. If this method is used to teach me for the rest of the time I have left I am very sure I will get grade A in WASSCE because I will always come to class and also learn maths always at prep and vacation time too.*

From participants' responses, they were of the view that if ICT integration approach is applied to them for the rest of their school days, they would have the motivation to study mathematics. They noted that if the ICT integration approach is employed by their mathematics teachers, it would have a significant impact on their internal examination performance as well as in their external examination (WASSCE). These responses suggested that ICT integration provides a conducive atmosphere for students to participate freely in the study of mathematics leading to increase in students' motivation. Finally, most of the participants suggested that if possible, ICT integration be made compulsory for all mathematics teachers in order to increase motivation in mathematics.

The interview results show that the students who were taught with ICT integration were motivated to study mathematics as evident in their responses to the questions they were asked. According to them the PowerPoint presentation of the concept created an atmosphere similar to that of a movie show and full of practicals and hence arousing their interest in learning. Moreover the results from the post-test show that participants who were taught using the ICT integration approach have improved significantly from their pre-test to post-test. These findings resonate strongly with the studies conducted by many researchers (Bettice, 2012; Passey & Rogers, 2004; Sparrow, Kissane & Hurst, 2010; Wong & Wong, 2017) who in separate studies, found that ICT integration in mathematics education promotes motivation of students through its practical nature and visual presentation of concepts.

Four mathematics teachers were also interviewed to elicit their views on how ICT integration promotes student' motivation in mathematics. The four teachers included two each from the two experimental groups where ICT was used in teaching the participants. They were made up of three males and one female.

All the mathematics teachers interviewed said they extensively use the traditional method, mostly board and marker/chalk illustrations in teaching their students. When asked why they prefer this method to student-centered methods most of them said that, with this method, they are able to cover more topics in the overloaded syllabus. Some also said that the traditional method best fits the teaching and learning environments in Ghanaian SHSs. Also most of the teachers lamented that they do not think their students are motivated by their method of teaching since most of their students do not like the subject. This was T02's response when he was asked this question:

> *I think mathematics is a problem to my students and many of them don't like attending my class because they feel that they cannot do It. Some of my students even tell me that they will be happy if mathematics is removed from the syllabus.*

T04 in her response when she was asked which method of teaching she mostly employ, said [*oh*] *for me I use the white board illustrations to explain concepts to my students and then we solve a lot of questions from textbooks.* When asked whether her method of teaching motivate her students to study mathematics, she reluctantly said *well, I think my students don't like mathematics because most of them don't come to class but I cannot tell if it's because of my method of teaching*.

This finding is in conformity with the study by Kalhotra, (2013) who found that most mathematics teachers use traditional teaching method especially the "chalk and board" method and only a small number of the students liked their teachers' method of teaching which results in lack of interest in the study of mathematics. This finding is also in agreement with the study conducted by Adamu & Sadiq, (2014) which found among other factors that lack of motivation among students in mathematics was a cause of the abysmal performance in WASSCE.

When asked whether they have ever integrating ICT in teaching mathematics in their entire period of teaching the subject, only one of the respondents (T01) said he has once integrated ICT in teaching mathematics in his present school. He remarked:

> *I have used ICT once to teach the Mensuration II concepts because it involves a lot of diagram and I am not good at drawing so ICT integration made it simple for me but anytime I want to use the lab, it's not available for use*".

When I asked whether his students were motivated when he integrated ICT in his teaching, he smiled confidently and said *yes, my students were very motivated and some even came to me severally asking when I was going to teach them using that method again*" when asked why he thinks his students were motivated, he said:

> *I think ICT presents concepts as if they are real because of its ability to present images very similar to the original. These qualities of ICT make students see the practicality of what they are studying and hence are motivated to study*.

When T03 was asked the question of whether he has ever integrated ICT into his teaching, he remarked *no, I have never done that before. It has not even crossed my mind*." When probed further, he said:

> *I have a fair knowledge in how to use ICT, especially PowerPoint presentations to teach certain mathematics concepts but I think the syllabus is too loaded for me to use ICT. Also, we have only one ICT lab which has been* [*hijacked*] *by the ICT teachers so I cannot use ICT in my teaching*.

When I asked him for his views on ICT integration as a tool for promoting students' motivation in mathematics, he said:

> Even *though I have not used it in teaching before, I think students will be motivated because they will be able to explore and see images of real life examples and hence the lesson will be very practical to them*.

Continuing, he said *children like practical activities and since ICT integration can provide that, I think they will be motivated*. These results tally with what the students said concerning how ICT motivated them to learn during the intervention stage. These results also resonates strongly with the findings of Wong and Wong (2017), that students are more motivated to learn mathematics when technology is appropriately integrated in the teaching and learning process.

Finally all the participants were of the view that all things being equal, if this method of teaching (ICT integration) is made conventional in Ghanaian SHSs, it would go a long way in boosting students' motivation in mathematics. T02 is his response to the question: All things being equal, would you prefer that this method of teaching is made the conventional method in boosting students' motivation in mathematics and why?, he confidently said: *sure, I think this method is the best and if it is made the conventional method, the problem relating to students fear of mathematics will be* *curbed*. T01, who earlier said he had integrated ICT once in his teaching was of the view that ICT integration is the surest way to tackle the problem of lack of interest in mathematics. In his response he lamented: *If government wants to tackle this problem of motivation, he must invest heavily in technology and provide all SHSs with mathematics laboratories where ICT can be put to work in order to help our students*.

In summary, the interviewees' stories shared here show that both students and mathematics teachers were of the view that ICT integration motivate students because of its ability to offer multiple representation of mathematical concepts, its practical presentation of concepts and promotion of retention through its "movie-like" presentation of mathematics concepts. The results also show that both students and mathematics teachers would like this method of teaching to be made conventional.

4.8. Discussion of Results

The purpose of this study was to investigate the effects of ICT integration on SHS students' motivation and achievement in mathematics in the Gomoa West district. The study also investigated whether ICT integration could bridge the achievement gap between students from endowed and less endowed SHSs in the district. The findings indicated that ICT integration as a mode of instruction provides students with new learning experiences in mathematics, particularly in teaching geometry concepts. These learning experiences included: enabling students visualize the concepts being taught, seeing real life images of concepts and relating them to their environment and allowing participants to work in groups and interact with each other by manipulating several exercises installed on the computers. This offered the participants new and interactive ways of learning mathematics concepts in a very conducive and inspired environment provided by technology.

The finding from the independent samples t-test (Table 13) analysis at $p = 0.775 > 0.05$ showed that there was no statistically significant difference in the participants' achievement levels in area and perimeter of plane shapes between the experimental group (school B) and the control group (school C) before the treatment was carried out. This indicated that both groups, which were both less endowed schools, were on the same level of achievement before treatment. Also, the findings from the independent samples t-test (Table 15) performed on the pre-test scores of the endowed and the less endowed school revealed a statistical significant difference $(p = 0.000 < 0.05)$ between the achievements of the two groups before the treatment. This indicated that the endowed school was at a higher achievement level in mathematics than the less endowed school. This finding is in line with the findings of many researchers (Adamu & Sadiq, 2014; Gegbe & Sheriff, 2015, Gitaari & Nyaga, 2013) who found that students from endowed schools performed better in mathematics than their counterparts in less endowed schools due to several factors they identified.

Again, the findings from the paired samples t-tests (Table 19), comparing the pre-test scores to the post-test scores of the three groups (two experimental and one control) showed that participants who were taught mathematics using the ICT integration method (Schools A and B), made more progress in the post-test than their counterparts (school C) who were taught using the traditional method. The eta squared values of 0.265, 0.298 and 0.108 for schools A, B and C respectively showed that the progress in the post-test scores of schools A and B who were taught using ICT integration approach was more than twice that of school C which was taught using the traditional instructional approach. These findings indicated that even though a well-structured traditional method could lead to improved performance in mathematics, integrating ICT in the teaching and learning process may double that improvement achieved through the traditional instruction. This finding is in line with the study by Tay and Mensah-Wonkyi, (2018) who found that participants in both the control and experimental groups improved significantly from their pre-test to post-test but those in experimental group who were exposed to lessons using ICT integrated instruction outperformed their counterparts exposed to the traditional method.

Furthermore, the finding from the independent samples t-test (Table 20) showed a statistically significant difference at $p = 0.005 < 0.05$ between the achievement in the post-tests of participants who were exposed to ICT integration approach ($Mean = 23.70$) in the experimental group and those exposed to the traditional approach ($Mean = 18.50$) in the control group. The difference in means between both groups comparatively was an indicator to the result that the experimental group outperformed the control group in the post-test. This finding revealed that when ICT is integrated in the teaching and learning of mathematics in less endowed schools, students' achievement is higher than when the traditional method is used. This finding strongly agrees with the studies by (Bhagat & Chang, 2015; Tay & Mensah-Wonkyi, 2018; Zengin, Furkan & Kutluca ,2012) who all in separate studies found students in the experimental group, who were exposed to lesson by incorporating Geogebra as a teaching strategy, improved significantly in the post-test as compared to their counterparts in the control group taught by the traditional method. However, the eta squared value of 0.096 showed a medium effect size. This may be as a result of the similarities that exist between these two less endowed schools (Control and Experimental) in terms of students' entry grade and socio-economic status, school facilities and parents/guardians educational level.

Also, the findings indicated that the endowed school exposed to lessons using ICT integration outperformed the less endowed school which was also exposed to lessons using the same teaching strategy as depicted by the independent samples t-test analysis performed on the post-test scores of the two groups (Table 21). The findings at $p = 0.000 < 0.05$ showed a statistically significant difference between the mean scores in the post-test of the endowed school $(Mean = 31.28)$ and the less endowed school $(Mean = 23.70)$. The eta squared value of 0.174 showed relatively large effect size. This result indicated that ICT integration into the teaching of mathematical concepts alone is not capable of bridging the gap between the academic achievements of endowed and less endowed schools in the district. Again this finding may be due the large differences that exist between endowed and less endowed SHSs in the district such as students' entry grade and socio-economic status, school facilities and educational level of parents/guardians.

Finally, the analysis of the interview data collected from both students and mathematics teachers point to several ways in which ICT integration motivates students in the mathematics classroom. Findings from the analysis of interview data revealed that ICT integration motivates students to study mathematics through its multiple representation abilities and practical nature. Responses from the student participants revealed that since ICT was integrated in the teaching and learning process, their study time have increased and they now spend a lot of time studying mathematics than they used to do. Also, all the mathematics teachers interviewed were of the view that ICT has a positive influence on SHS students' interest to study mathematics. These findings are consistent with findings of a research report published by Lancaster University on a study conducted by Passey and Rogers (2004) which found several motivational benefits of ICT integration including; students concentrating on the learning process rather than a mere completion of tasks, offering a means for a range of pupils to envisage success, better behavior of students towards the learning process as well as teachers' view that ICT has positive influence on students interest to complete mathematics tasks. These findings are also consistent with the findings from the study by Wong and Wong (2017) which found that technology is a potential tool for motivating students to study mathematics and that technology enhanced learning can be used to enhance students' self-efficacy which is a core determinant of students' motivation in mathematics.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0. Overview

This is the final chapter of this research study. The chapter provides the summary of the study and highlights the major findings. It also highlights the conclusion of the study, implications for practice and further outlines some recommendations and directions for future research.

5.1. Summary of the Study

The study investigated the effects of ICT integration on students' motivation and achievement in mathematics in endowed and less endowed schools in the Gomoa West district.

The following research questions guided the study:

1. What is the effect of ICT integration on SHS students' achievement in mathematics in contrast to the traditional method?
2. To what extent does ICT integration bridge the gap in the achievement of students in endowed and less endowed SHSs?
3. In what ways do ICT integration motivate students to study mathematics at the SHS level?

The study employed the quasi experimental research design as a strategy of enquiry by employing the embedded mixed method approach. Geometry Achievement Tests (GAT) and semi-structured interview guides were the instruments used in data collection. Data collected largely involved quantitative data but qualitative data was also collected to support the quantitative data. The population consisted of all second year SHS students in the Gomoa West district of the central region. A sample of 120 students were selected using systematic random sampling technique from three SHSs in the district for the study. The sample comprised of 40 students in the control group (school C), 40 students in the endowed experimental group (school A) and 40 students in the less endowed experimental group (school B). Six students were selected randomly from the experimental groups while four mathematics teachers were selected purposively for interview. After the pre-test, the experimental groups were exposed to a four-week treatment with ICT integration approach to teaching while the control was exposed to the traditional approach of teaching for the same period. A post-test, which consisted of similar questions to the pre-test was administered after the treatment. The results of the different data sources including the pre-test and post-test (GAT) and Interviews were combined to answer the research questions that guided the study. Specifically, each research question was looked at from all relevant data sources.

5.2. Major Findings

The major findings of the study are classified according to the research questions. They are presented under the three sub-headings in line with the research questions (RQ) in this section

5.2.1. RQ 1: What is the effect of ICT integration on SHS students' achievement in mathematics in contrast to the traditional method?

Findings from the pre-test and post-test analysis revealed that the participants in the experimental group (school B) outperformed their counterparts in the control group (school C) after treatment. The findings also revealed a statistically significant difference in the mean scores between the experimental and control groups in the post-test comparison. The findings further revealed that both groups improved in their post-test scores as compared to the pre-test but the experimental group improved more significantly.

5.2.2. RQ 2: To what extent does ICT integration bridge the gap in the achievement of students in endowed and less endowed SHSs?

The findings from the analysis of the pre-test and post-test scores of the endowed experimental group (school A) and the less endowed experimental group (school B) who were both taught using ICT integration showed that the endowed group outperformed the less endowed group. The findings from the independent samples t-test analysis revealed a significant difference in the mean scores of the two groups. The findings to this research question indicated that ICT integration into the teaching and learning of mathematical concepts alone could not bridge the gap between the academic achievement of students in endowed and less endowed schools.

5.2.3. RQ 3: In what ways do ICT integration motivate students to study mathematics at the SHS level?

The findings from interviewees' responses revealed that both students and mathematics teachers were of the view that ICT integration into teaching and learning of mathematics promotes students' motivation. According to the findings, the following revelations came to light; ICT integration makes the learning process practical, it engages students in the teaching process, it presents concepts in multi-dimensional way, it reduces the burden on students in terms of notes copying, it promotes retention through its visualizing qualities, it brings the students' immediate environment closer to the classroom and it creates a very conducive student-centered teaching and learning environment. All these attributes of ICT integration instruction contributed to students' motivation in mathematics.

5.3. Conclusion

The main contribution of this study is new knowledge about the effects of ICT integration on SHS students' motivation and academic achievement in endowed and less endowed schools. In this research study, participants in the experimental groups were taught lessons in mathematics with ICT integrated into the teaching and learning process while participants in the control group were taught by traditional instructional approach. Participants in both experimental and control groups showed increment in their post-test scores as compared to the pre-test scores. However, participants in the experimental group outperformed those in the control group. That is, it can be claimed that ICT integration in teaching of mathematics concepts has a positive effect on SHS students' achievement in mathematics. The practicality of the lessons provided by ICT integration led to the conceptual understanding of the concepts taught and eventually improved students' performance in the post-test. This finding is in line with earlier studies (Bhagat & Chang, 2015; Eyyam & Yaratan, 2014; Meng & Idris, 2012; Safdar et al., 2011; Tay & Mensah-Wonkyi, 2018; Zengin et al., 2012) on the effects of ICT integration on students' achievement in mathematics, specifically in teaching and learning geometry. All these studies found that ICT integration in various forms in mathematics education improved academic achievement in mathematics. ICT integration in the teaching and learning of mathematics has the potential of improving students' academic achievement in both endowed and less endowed schools.

Another major finding in this study was that ICT integration in teaching mathematics could not bridge the gap between the achievements of students in endowed and less endowed SHSs. This finding indicated that when ICT was integrated in teaching students in endowed and less endowed schools, the achievement of students from the endowed school was better than those from the less endowed school. In other words it can be claimed that ICT integration alone cannot bridge the gap between students' achievement and that there are other factors that contribute to this achievement gap. However, the findings showed that ICT integration led to improvement in achievements of students from both endowed and less endowed schools as reflected in the mean difference between their post-test and pre-test scores.

In this study it was also revealed that ICT promotes motivation of students in studying mathematics. ICT integration was found to make the learning process more practical, engages students in the teaching process, presents concepts in multi-dimensional way, reduces the burden on students in terms of notes copying, promotes students' retention, brings students' immediate environment closer to the classroom and creates a very conducive student-centered teaching and learning environment. This finding resonates strongly with past studies (Bettice, 2012; Passey & Rogers, 2004; Sparrow, Kissane & Hurst, 2010; Wong & Wong, 2017) on motivational benefits of ICT integration in mathematics education. Findings from these studies pointed out that ICT has the potential of promoting motivation of students in learning of mathematics.

Also, findings from interviewees' responses revealed that the students enjoyed the lessons taught with ICT integration approach than the traditional method employed by their mathematics teachers in the class. This according to them has led to increase in their study time for mathematics and wish this method is made compulsory for all mathematics teachers. However, the interview data collected from mathematics teachers indicated that the traditional method dominates teaching and learning of mathematics in Ghanaian SHSs although most mathematics teachers claimed that they have fair knowledge on how to integrate ICT and its tools in the teaching process.

This finding is in line with past studies (Gegbe et al., 2015; Kalhotra, 2013; Mbugua et al. 2012; Sa'ad et al., 2014) on factors causing SHS students poor performance in mathematics. This is rather a worrying situation especially at a time when SHS students' performance in WASSCE continue to drop.

5.4. Recommendations

The following recommendations are made based on the findings of this study:

- Government through the Ministry of Education and the Ghana Education Service (GES) should consider establishing a mathematics laboratory in all SHSs in the country furnished with at least a computer and LCD projector to make ICT integration possible. This suggestion is made based on the finding that there was no mathematics laboratory in any of the SHSs in the district where the study was carried out. Also, most mathematics teachers interviewed said they do not integrate ICT because the ICT laboratory is always in use by ICT teachers.
- Curriculum developers and policy makers need to take a critical look at the ICT integration policies and make them relevant to subject specific areas, such as mathematics. This is in view of the finding that ICT can improve academic performance of students and motivate students from both endowed and less endowed SHSs in Ghana.
- Stakeholders in education at the SHS level should consider organizing Seminars/workshops intermittently for Mathematics teachers on the use of appropriate technological tools such as PowerPoint presentations in the teaching and learning of mathematical concepts, especially geometry, by experts in the field. This recommendation is made because it was found that

most mathematics teachers tend to use the traditional method because of its ease of use.

- Mathematics teachers using the traditional instructional approach in teaching should be encouraged to structure it well by creating conducive teaching and learning atmospheres to promote students' participation. This suggestion is made based on the finding that students who were taught by a well-structured traditional approach also improved significantly in the post-test.

5.5. Areas for Further Research

The findings of this study brings to bear a lot of related educational implications. These implications of the findings of this study calls for further research involving ICT integration in teaching and learning of mathematics in Ghana. The following areas are suggested for further research:

- This study used samples from SHSs in one district in the central region (Gomoa West) of Ghana. A study in this area can be undertaken in other districts in the central region as well as in other regions of Ghana.
- This study also found that ICT integration alone could not bridge the gap between the achievements of students from less endowed and endowed schools in mensuration I in the Gomoa West district. A study in this area can be undertaken in other districts and in other regions to comprehend the general picture of this phenomenon.
- Finally, a study in this area can be done to investigate other areas of geometry such as mensuration II (surface area and volume of three-dimensional figures) and circle theorems as well as other concepts in SHS mathematics syllabus to obtain a general picture of the effects ICT integration in mathematics on students' achievement.

REFERENCES

Abreh, M. K,Owusu, K. A & Amadahe, F. K. (2018). Trends in performance of WASSCE candidates in science and mathematics in Ghana: Perceived contributing factors and the way forward. *Journal of Education, 198*(1), 113-123.

Abu, M. S. & Abidin, Z. Z. (2013). Improving the levels of geometric thinking of secondary school students using geometry learning video based on Van Hiele theory. *International Journal of Evaluation and Research in Education (IJERE).* 2(1): 16-22.

Adikwu, A. M, Ogwuche, C. O & Friday, I. (2018). Assessment of secondary school teachers' use of ICT in Anyingba Metropolis, Kogi state, Nigeria. *Journal of Education and Entrepreneurship, 5*(1), 32-47.

Agyei, D. D. (2013). Analysis of technology integration in teacher education in Ghana. *Journal of Global Initiatives: Policy,, 8*(5). Retrieved from http://digitalcommons.kennesaw.edu/jgi/vol8/iss1/5

Agyemang M. and Mereku D. K. (2015). Technology use among Ghanaian senior high school mathematics teachers and the factors that influence it. *African Journal of Educational Studies in Mathematics and Sciences, 11*, 31-42.

Alex, J. K. & Mammen, K. J. (2012). A Survey of South African grade 10 learners' geometric thinking levels in terms of the Van Hiele theory. *Anthropologist.* 14(2): 123-129.

Amanor, L. (2014). *Impact of ICT on teaching and learning of Mathematics in senior high schools in new Juaben Municipality (unpublished mater's thesis).* Winneba-Ghana: University of Education, Winneba.

Aremu, A. O., Sokan, B. O. (2003). *A multicausal evaluation of academic performance of Nigerian learners: Issues and implications for national development.* Ibadan: Department of Guidance and Counselling, University of Ibadan.

Armah, R. B, Cofie, P. O & Okpoti, C. A. (2017). The geometric thinking levels of pre-service teachers in Ghana. *Higher Education Research, 2*(3), 98-106. Retrieved from http://www.sciencepublishinggroup.com/j/her

Asiedu-Addo, S. K, Apawu, J, Owusu-Ansah, N.A & Armah, G. (2016). The usage of ICT in the teaching and learning of mathematics: Tracer study of mathematics educators. *Journal of Science Education and Research, 2*(1), 44-57.

Baffoe, E. & Mereku, D. K. (2010). The Van Hiele levels of understanding of students entering senior high school in Ghana. *African Journal of Educational Studies in Mathematics and Sciences.* 8: 51-61.

Bakare, C. G. (1994). *Mass failure in public examinations: Some psychological perspectives.* Ibadan: Department of Guidance and Counselling, University of Ibadan.

Bates, T. (2014, December 10). *A short history of educational technology*. Retrieved from Online Learning and Distance Education Resources: www.tonybates.ca/2014/12/10/a-short-history-of-educational-technology

Bettice, K. (2012). Student motivation in the high school mathematics classroom; How can we motivate students in the mathematics classroom in order to create a more effective learning environment? *Education Senior Action Research Projects: Department of Education, Valparaiso University*, 1-2.

Bhagat, K. K & Chang, C-Yen. (2015). Incorporating geoGebra into geometry learning - A lesson from India. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(1), 77-86.

Blege, A. (2014, September 5). Continuous poor performance at the WASSCE; something must be wrong. Accra, Ghana. Retrieved April 4, 2018, from https://www.graphic.com.gh/features/features/continuous-poor-performance-at-the-wassce.html.

Board of School of Graduate Studies. (2016). *General guidelines for preparation and submission of thesis, dissertations and project reports for higher degrees.* Winneba: University of Education Press.

Bosson-Amedenu, S. (2018). Effect of use of WAEC syllabus on the mathematical achievement of WASSCE candidates in Ghana. *Asian Research Journal of Arts and Social Sciences, 6*(4), 1-8.

Bourne, D. T. (2017, July). *An investigation of senior secondary school teachers' experiences of integrating information and communication technologies into teaching and learning in the era of Australia's digital education revolution.* Retrieved from University of Wollongong Research Online: http://ro.uow.edu.au/theses1/76

Buabeng-Andoh, C. (2012). Factors influencing teachers' adoption and integration of Information and Communication Technology into teaching: A review of the literature. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT), 8*(1), 136-155.

Chao, G. M. (2015). Impact of teacher training on Information Communication Technology integration in public secondary schools in Mombasa County. *Human Resource Management Research, 5*(4), 77-94.

Cohen, L., Manion, R. and Morrison, K. (2007). *Research Methods in Education* (6 ed.). New York: Routledge.

Creswell, J. W. (2012). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4 ed.). Boston, MA: Pearson Education, Inc.

Crossman, A. (2018, 04 01). *Understanding purposive sampling: An overview of methods and its applications.* Retrieved from www.thoughtco.com: http://www.thoughtco.com/purposive-sampling-3026727.

Descombe, M. (2010). *The good research guide for small-scale social research projects* (4 ed.). Berkshire, England: Open University Press.

Duru, A., Peker, M. & Birgin, O. (2012). Investigation of pre-service teachers` attitudes toward using the computer in teaching and learning mathematics. *The New Educational Review, 27*(1), 283-291

Dzakadzie, Y. (2017). *Rudients of educational measurement evaluation and statistics* (2nd ed.). Kumasi: Benjoy Ent.

Dziekpor, B. (2014). *The mathematics teachers and students use of technology in Ghana SHS (Unpublished master's thesis).* University of Education, Winneba: Winneba - Ghana.

Eyyam, R. & Yaratan, H.S. (2014, January). Impact of use of technology in mathematics lessons on student achievement and attitudes. *Journal of social behavior and personality, 42*, S31-S42.

Fredua-Kwarteng, Y. and Ahia, F. (2005). *ghanaweb.* Retrieved 12 01, 2017, from Ghanaweb: www.ghanaweb.com/Confronting national mathematics phobia in Ghana (part 2)

Gegbe, B., Sundai, A., & Sheriff, V. K. (2015, March-April). Factors contributing to students poor performance in mathematics at West African Senior School Certification Examination (A case study: Kenema City, Eastern Province Sierra Leone). *International Journal of Engineering Research and General Science, 3*(2), 1040-1055.

Ghavifekr, S.,Razak, A. Z., Ghanai, M. F.,Ran, Y., Meizi, Y., & Tengyue, Z. (2014). ICT integration in education: Incorporation for teaching and learning improvement. *The Malysian Online Journal of Educational Technology, 2*(2), 24 - 45

Gitaari, E. M. & Nyaga, G. (2013). Factors contributing to students poor performance in mathematics in public secondary schools in Tharaka South district, Kenya. *Journal of Education and Practice, 4*(7), 93-99.

Glen, S. (2016). *StatisticsHowTo.* Retrieved from StatisticsHowTo.com: www.statisticshowto.datasciencecentral.com/test-retest reliability/

Goos, M. (2010). Using tehnology to support effective mathematics teaching and learning: What counts? *University of Queensland Research Conference 2010* (pp. 67-70). Australia: University of Queensland Press.

Igun, S. (2013). Gender and national information communication and technology. In B. &. Maumbe, *Technology, Sustainability, and rural development in Africa* (pp. 284-297). Hershey, PA: Information Science Reference.

Jacob, S. A & Furgerson, S. P. (2012). Writing interview protocols ans conducting interviews: Tips for students new to the field of qualitative research. *The qualitative report, 17*(T&L.6), 1-10.

Kayyulilo, A. C., Fisser, P., Voogt, J. (2015). Supporting teachers learning through the collaborative design of technology-enhanced science lessons. *Journal of Science Teacher Education*, 674-694

Kalhotra, S. (2013). A Study of causes of failure in mathematics at high school stage. *Academic Research International, 4*(5), 588-599.

Kalhotra, S. K. (2013, September). A study of causes of failure in mathematics at high school stage. *Academic Research International, 4*(5), 588-599.

Kearsley, G., & Shneiderman, B. (1998). Engagement Theory: A Framework for Technology-Based Teaching and Learning. *Educational Technology, 38*(5), 20-23. Retrieved March 20, 2018, from www.jstor.org/stable/44428478

Kumah, M. S., Akpandja, T. K., Djondo, B. I. & Kumi, J. (2016). Factors contributing to the poor performance in mathematics: The case study among students of colleges of education - Ghana. *Researchjournali's Journal of Mathematics, 2*(3), 1-12.

Marban, J. M., Mulenga, E. M. (2019). Pre-service primary teachers' teaching styles and attitudes towards the use of technology in mathematics classrooms. *International Electronic Journal of Mathematics Education, 14*(2), 253-263.

Martin, M. O., Mullis, I. V. S. (Eds.). *(2011). Methods and procedures in TIMSS and PIRLS 2011*. Retrieved on 12th January, 2019 from http://timssandpirls.bc.edu/methods/index.html

Marshall, S. (2007). Engagement Theory, WebCT, and academic writing in Australia. *International journal of Education and Development using Information and Communication Technology, 3*(2), 109 - 115.

Mbugua, Z. K., Kibet, K., Muthaa, G. M. & Nkonke, G. R. (2012, June). Factors contributing to students' poor performance in mathematics at Kenya Certificate of Secondary Education in Kenya: A case of Baringo County, Kenya. *American International Journal of Contemporary Research, 2*(6), 87-91.

Mbugua, Z.K, Kibet, K, Muthaa, G.M. & Nkonke, G.R. (2012). Factors contributing to students' poor performance in mathematics at Kenya Certificate of Secondary Education in Kenya: A Case of Baringo County, Kenya. *American International Journal of Contemporary Research, 2*(6), 87-91.

McLeod, S. (2014). *SimplyPsychology*. Retrieved from SimplyPsychology website: www.simplypsychology.org/interviews.html

Meng, C. C. & Idris, N. (2012). Enhancing students' geometric thinking and achievement in solid geometry. *Journal of Mathematics Education, 5*(1), 15-33.

Mensah, F. (2017). Ghanaian mathematics teachers' use of ICT in instructional delivery. *Global Journal of Human-Social Science, 17*(8), 30-42.

Mensah-Wonkyi, T. & Adu, E. (2016). Effect of the enquiry-based teaching approach on students' understanding of circle theorems in plane geometry. *African Journal of Educational studies in Mathematics and Sciences*, 12, 61-73.

Miles, J. & Shevin, M. (2001). *Applying regression and correlation: A guide for students and researchers*. Sage: London

Ministry of Education (MoE). (2007). *Teaching syllabus for core mathematics (Senior High School).* Accra-Ghana: Curriculum Research and Development Division (CRDD).

Ministry of Education (MoE). (2010). *Teaching syllabus for core mathematics (Senior High School).* Accra-Ghana: Curriculum Research and Development Division (CRDD).

Ministry of Education. (2008). *ICT in education policy.* Accra: Ministry of Education (MOE).

Ministry of Education, (MOE). (2015). *ICT in education policy.* Accra: Ministry of Education.

Mullis, I. V., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Ndebalima, P. (2014). Teachers attitudes towards the use of Information Communication Technology (ICT) as a pedagogical tool in secondary schools in Tanzania: The case of Kondoa district. *International Journal of Education and Research, 2*(2), 1-16.

Ogundele, G.A, Olanipekun, S. S & Aina, J. K. (2014). Causes of poor performance in West African School Certificate Examination (WASCE) in Nigeria. *Scholars Journal of Arts, Humanities and Social Sciences, 2*(5B), 670-676.

Pantziara, M., & Philippou, G. N. (2013). Students' motivation in the mathematics classrooms: Revealing the causes and consequences. *International Journal of Science and Mathematics Education, 13*, 385-411.

Passey, D. & Rogers, C. (2004). *The motivational effect of ICT on pupils.* London: Department of Educational Research, Lancaster University.

Piper, B., Jepkemei, E., Kwayumba, D. & Kibukho, K. (2015). Kenya's ICT policy in practice. The effectiveness of tablets and E-readers in improving student outcomes. *FIRE: Forum for International Research in Education, 2*(1), 3-18.

Rani, R. & Aisha. (2017). Construction and Standardization of Mathematics Achievement Test for IXth Grade Students. *Educational Quest: An Int. J. of Education and Applied Social Science, 8*(2), 651-655

Republic of Ghana. (2003). *The Ghana ICT for accelerated development (ICT4AD) Policy.* Accra: Government of Ghana.

Ron, M. Y. (2009, March 20). *The Effects of the use of technology in mathematics instruction on student achievement.* Retrieved from digitalcommons: http://digitalcommons.fiu.edu/etd/136

Ross, S. (2019, May 8). *Investopedia*. Retrieved from https://www.investopedia.com: https://www.investopedia.com/ask/answers/042415/what-are-advantages-and-disadvantages-using-systematic-sampling.asp

Sa'ad, T. U., Adamu, A & Sadiq, A. M. (2014). The causes of poor performance in mathematics among public senior secondary school students in Azare Metropolis of Bauchi State, Nigeria. *IOSR Journal of Research & Method in Education (IOSR-JRME), 4*(6), 32-40. Retrieved from www.iosrjournals.org

Safdar, A., Yousuf, M. I., Malik, Q. P. & Behlod, G. (2011). Effectiveness of Information and Communication Technology in teaching mathematics at the secondary level. *International Journal of Academic Research 3(5),* 67-72.

School of Graduate Studies (SGS). (2018). *University of Education, Winneba (UEW) policies for postgraduate students.* Winneba: UEW Printing Press.

Schunk, D.H., Pintrich, P.R & Meece, J. (2014). *Motivation in education: Theory, research and applications.* (pp. 1-5). Boston: Pearson

Simon, M. K. (2011). *Dissertation and scholarly research: Recipes for Success* (2011 ed.). Seattle, WA: Dissertation Success, LLC.

Sparrow, L., Kissane, B., & Hurst, C.(Eds). (2010). Shaping the future of mathematics education. *Proceedings of the 33rd annual conference of the Mathematics Education Research Group of Australasia* (pp. 681-689). Fremantle : MERGA.

Tarmizi, R. A., & Tarmizi, M. A. (2010). Analysis of mathematical beliefs of Malaysian secondary school students. *Procedia Social and Behavioral Sciences, 2*, 4702-4706.

Tay, M. K, & Mensah-Wonkyi, T. (2018). Effect of using geogebra on senior high school students' performance in circle theorems. *African Journal of Educational Studies in Mathematics and Sciences, 14*, 1-17.

Tilya, F. (2008). IT and educational policy in the sub-Saharan African region. In &. G. J. Voogt, *International handbook of information technology in primary and secondary* (pp. 1145–1159). New York, NY: Springer

UNESCO. (2007). *ICT in education in the Asia-pacific region: Progress and plans.* Bangkok, Thailand.: UNESCO Asia and Pacific Regional Bureau for Education.

WAEC. (2014). *West African Senior School Certificate Examinations chief examiner's report for core mathematics.* Accra: West African Examination Council

WAEC. (2015). *West African Senior School Certificate Examinations chief examiner's report for core mathematics.* Accra: West African Examination Council

WAEC. (2016). *West African Senior School Certificate Examinations chief examiner's report for core mathematics.* Accra: West African Examination Council.

WAEC. (2017). *West African Senior School Certificate Examinations chief examiner's report for core mathematics.* Accra: West African Examination Council.

WAEC. (2018). *West African Senior School Certificate Examination chief examiner's report for core mathematics.* Accra: WAEC.

Wong, S. L & Wong, S. L. (2017). Motivation towards mathematics learning in the Technology-Enhanced environment. *Hayashi, Y., et al. (Eds.). Workshop Proceedings of the 25th International Conference on Computers in education* (pp. 109-115). New Zealand: Asia-Pacific Society for Computers in Education.

Yu, R., & Singh, K. (2016). Teacher support, instructional practices, student motivation, and mathematics. *The Journal of Educational Research*, 1-14.

Zengin, Y., Furkan, H., and Kutluca, T. (2012). The effect of dynamic mathematics software geogebra on students' achievement in teaching trigonometry. *Procedia - Social and Behavioral Sciences, 31*, 183-187.

APPENDICES

APPENDIX A: GEOMETRY ACHIEVEMENT TEST (GAT) PRE-TEST

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO. While you are waiting, read carefully the following instructions.

INSTRUCTIONS

1. Write the **name of your school** and **class** in the spaces provided below.
2. This test is in two parts, **Part I** and **Part II**. Answer all questions in both sections. There are **20** multiple choice questions in **Part I**, write the right option from options lettered A to D in the **box provided** against it.
3. There are **3** questions in Part II, write your solutions to every question in the spaces provided.
4. You will have **60** minutes to complete both Part I and II. You are advised to use **at most** 30 minutes in Part I.

SCHOOL: ……………………………………………………………………

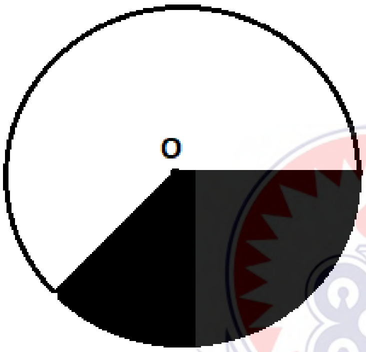
CLASS: ……………………………………………………………………

PART I

Answer all the questions in this part. Write the correct option to each question in the box provided

1. The total distance around the outer edges of the circle is referred to as …………..
   A. Area
   B. radius
   C. circumference
   D. chord

2. In the diagram below, O is the center of the circle. What name is given to the unshaded portion?



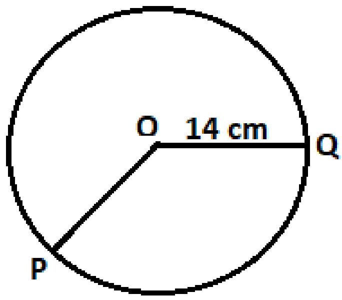
   A. Segment
   B. Sector
   C. Arc
   D. circumference

3. Find the circumference of a circle whose diameter is 28cm. $\left[Take\ \pi = \frac{22}{7}\right]$
   A. 22cm
   B. 44cm
   C. 88cm
   D. 176cm

4. A bicycle wheel has a perimeter of 63m. Find, correct to the nearest meter, the diameter of the wheel $\left[Take\ \pi = \frac{22}{7}\right]$
   A. 19 m
   B. 20 m
   C. 21m
   D. 22 m

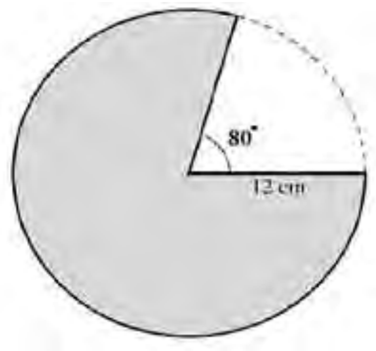
5. The sum of the circumference and the radius of a circle is 51cm. Find the diameter of the circle. $\left[Take\ \pi = \frac{22}{7}\right]$.
   A. 7 cm
   B. 14 cm
   C. 21 cm
   D. 28 cm

6. In the diagram below, PQ subtends an angle of 100° at the center O of the circle. Calculate the length of the minor arc $|PQ|$ in terms of π.



   A. $\frac{70}{9}\pi\ cm$
   B. $\frac{140}{9}\pi\ cm$
   C. $\frac{182}{9}\pi\ cm$
   D. $\frac{28}{9}\pi\ cm$

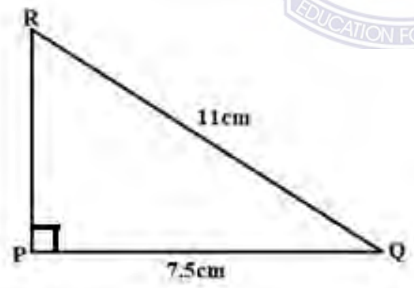
7. Find the perimeter, correct to 3 significant figures, of the unshaded sector of the circle shown below. $\left[Take\ \pi = \frac{22}{7}\right]$.



A. 82.7 cm
B. 40.8 cm
C. 58.7 cm
D. 16.8 cm

8. The width of a rectangular field is 15m. If the perimeter of the field is 98 m, find the length of the field.
   A. 68 m
   B. 34 m
   C. 30m
   D. 42 m

9. The diagram below is a right angled triangle. Calculate its perimeter, correct to one decimal place.



   A. 16.5 cm
   B. 26.5 cm
   C. 36.5 cm
   D. 46.5 cm

10. The perimeter of a rhombus is 146 cm and the length of one of its diagonals is 48 cm. Find the length of its other diagonal.
   A. 27.5 cm
   B. 55.0 cm
   C. 30.0 cm
   D. 36.5 cm

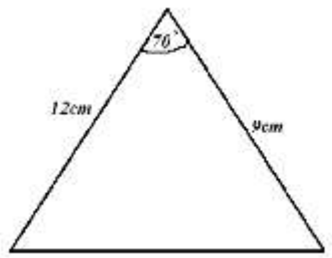
11. The radius of a circle is 11cm long. Find the circumference of the circle in terms of π ?
   A. 11π cm
   B. $\frac{11}{2}\pi$ cm
   C. 22π cm
   D. 44π cm

12. A circle of diameter 28 m is divided into four equal sectors. Find the area of one sector, correct to the nearest square meter. $\left[Take\ \pi = \frac{22}{7}\right]$.
   A. 11 m^2
   B. 49 m^2
   C. 77 m^2
   D. 154 m^2

13. The perimeter of a square is twice the perimeter of a rectangle of length 12cm and width 8cm. find the length of the sides of the square.
   A. 20 cm
   B. 15 cm
   C. 10 cm
   D. 5 cm

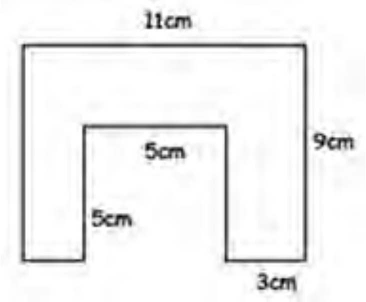
14. The area of a circle is 154 m^2. Find the radius of the circle. $\left[Take\ \pi = \frac{22}{7}\right]$.
   A. 14 m
   B. 24 m
   C. 7 m
   D. 49 m

15. Find the area of the triangle below



A. 39.74 cm^2
B. 50.74 cm^2
C. 41.74 cm^2
D. 42.74 cm^2

16. An arc subtends an angle of 135^0 at the center of the circle. If the radius of the circle is 20cm, find the area of the minor sector of the circle. [Take $\pi = 3.14$].
    A. 471.0 cm^2
    B. 785.0 cm^2
    C. 47.1 cm^2
    D. 78.5 cm^2
17. The area of a kite is $260cm^2$. If the length of one of the diagonals is 26cm, find the length of the other diagonal.
    A. 30 cm
    B. 20 cm
    C. 15 cm
    D. 10 cm
18. The parallel sides of a trapezium are 9.9cm and 8.3cm long. If the height of the trapezium is 7cm, find the area of the trapezium.
    A. 51.4 cm^2
    B. 63.7 cm^2
    C. 33.4 cm^2
    D. 156 cm^2
19. Find the area of the figure below



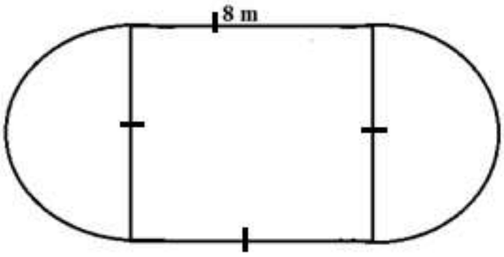
    A. 74 cm^2
    B. 40 cm^2
    C. 94 cm^2
    D. 82 cm^2
20. The area of a parallelogram is $151.2 cm^2$. If the height is 11.2 m, find the length the base of the parallelogram.
    A. 9.5 cm
    B. 10.5 cm
    C. 13.5 cm
    D. 12.5 cm

END OF OBJECTIVE TEST

PART II

Please provide answers to all the questions in this part. Answers to each question should be shown clearly together with rough work in the spaces provided.

1. The diagram below is a school lawn in the form of a square of sides 8m and two semi-circular ends. Calculate correct to 2 decimal places;



   a) The perimeter of the lawn

   b) The area of the lawn. $\left[Take\ \pi = \frac{22}{7}\right]$.

2. The perimeter of a rhombus is 38cm. if the length of one diagonal is 16cm, find the area of the rhombus.

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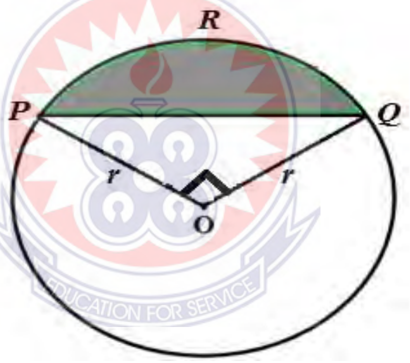
3. In the diagram, O is the centre of the circle of radius 9.8 cm and $\angle XOY = 90^\circ$. Calculate correct to 3 significant figures,
   a) The area of sector POQR.
   b) The area of the shaded portion. $\left[Take\ \pi = \frac{22}{7}\right]$.



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APPENDIX B - GEOMETRY ACHIEVEMENT TEST (GAT) POST-TEST

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE TOLD TO DO SO. While you are waiting, read carefully the following instructions.

INSTRUCTIONS

5. Write the **name of your school** and **class** in the spaces provided below.
6. This test is in two parts, **Part I** and **Part II**. Answer all questions in both sections. There are **20** multiple choice questions in **Part I**, write the right option from options lettered A to D in the **box provided** against each question.
7. There are **4** questions in Part II, write your solutions to every question in the spaces provided.
8. You will have **60** minutes to complete both Part I and II. You are advised to use **at most** 30 minutes in Part I.

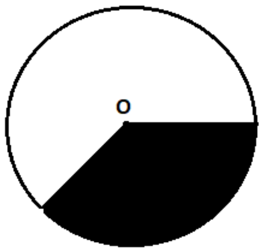
SCHOOL: ……………………………………………………………………………

CLASS: ……………………………………………………………………………..

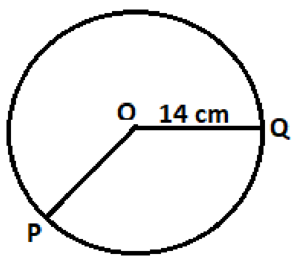
PART I

Answer all the questions in this part. Write the correct option to each question in the box provided.

1. The circumference of a circle refers to:
    A. The total area of the circle
    B. The line segment from the center of the circle to any part of the outer edge
    C. The space occupied by the circle
    D. The total distance around the outer edges of the circle
2. Find the circumference of a circle whose radius is 28cm. $\left[Take\ \pi = \frac{22}{7}\right]$
    A. 22cm
    B. 44cm
    C. 88cm
    D. 176cm
3. A circular field has a circumference of 132m. Find the distance that one has to walk from the edge to the center of the field. $\left[Take\ \pi = \frac{22}{7}\right]$
    A. 19 m
    B. 20 m
    C. 21 m
    D. 22 m
4. The difference between the circumference and the diameter of a circle is 30 m. Find the radius of the circle. $\left[Take\ \pi = \frac{22}{7}\right]$.
    A. 7 cm
    B. 14 cm
    C. 21 cm
    D. 28 cm
5. In the diagram below, O is the center of the circle. What name is given to the shaded portion?

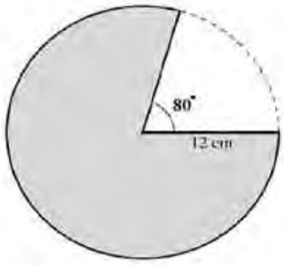


    A. Segment
    B. Sector
    C. Arc
    D. circumference
6. In the diagram below, PQ subtends an angle of 120° at the center O of the circle. Calculate the length of the major arc $|PQ|$ in terms of π.



    A. $\frac{4}{3}\pi\ cm$
    B. $\frac{14}{3}\pi\ cm$
    C. $\frac{28}{3}\pi\ cm$
    D. $\frac{56}{3}\pi\ cm$
7. Find the perimeter, correct to 3 significant figures, of the

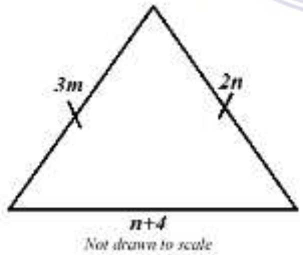
shaded sector of the circle shown below. $\left[Take\ \pi = \frac{22}{7}\right]$.



A. 82.7 cm
B. 75.4 cm
C. 58.7 cm
D. 40.8 cm

8. The length of a rectangular field is 15 m longer than the width. If the perimeter of the field is 380 m, find the length of the field.
   A. 72.5 m
   B. 87.5 m
   C. 102.5 m
   D. 115.0 m

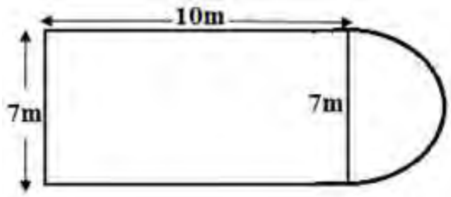
9. In the diagram below, the perimeter of the triangle is 19 cm. Find the values of m and n



   A. $m = 2, n = 3.$
   B. $m = 3, n = 2.$
   C. $m = 4, n = 6.$
   D. $m = 6, n = 4.$

10. The diagonals of a rhombus are 8cm and 10cm long. Calculate, correct to 1 decimal place, the perimeter of the rhombus.
   A. 25.0 cm
   B. 25.6 cm
   C. 22.5 cm
   D. 12.5 cm

11. The diagram below represents a compound which is made up of a rectangle portion, 7m by 10m and a semi-circle portion. Calculate the perimeter of the compound, correct to the nearest metre. [Take $\pi = 3.142$]



   A. 70 m
   B. 45 m
   C. 34 m
   D. 38 m

12. A circular lawn of radius 14 m is divided into six equal sectors. Find the area of each sector, correct to the nearest square meter. $\left[Take\ \pi = \frac{22}{7}\right]$.
   A. 100 m^2
   B. 616m^2
   C. 103m^2
   D. 102m^2

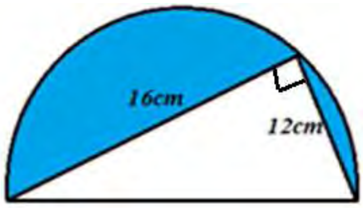
13. The area of a circle is 154 cm^2. Find the circumference of the circle. $\left[Take\ \pi = \frac{22}{7}\right]$.
   A. 22 cm
   B. 24 cm
   C. 44 cm
   D. 49 cm

14. A bicycle wheel has a perimeter of 63 m. Find, correct to the nearest meter, the diameter of the wheel $\left[Take\ \pi = \frac{22}{7}\right]$

A. 19 m
B. 20 m
C. 21m
D. 22 m

The diagram below shows a semi-circle and a triangle inscribed in it. Use it to answer questions 15 and 16.

$\left[Take\ \pi = \frac{22}{7}\right]$



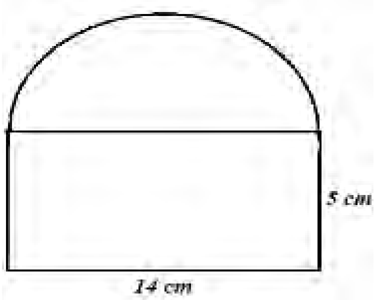
15. Find the area of the shaded portion, correct to the nearest whole number
    A. $194cm^2$
    B. $122cm^2$
    C. $61cm^2$
    D. $37cm^2$
16. Find the perimeter of the shaded portion, correct to the nearest whole number
    A. 59 cm
    B. 51 cm
    C. 48 cm
    D. 31 cm
17. In a circle, a chord of length $16\sqrt{3}cm$ is 10 cm from the center of the circle. Find the radius of the circle.
    A. 20.1 cm
    B. 19.1 cm
    C. 18.1 cm
    D. 17.1 cm
18. An arc subtends an angle of 100^0 at the center of the circle. If the radius of the circle is 12cm, find the area of the minor segment of the circle. $\left[Take\ \pi = \frac{22}{7}\right]$.
    A. $134.6\,cm^2$
    B. $125.7\,cm^2$
    C. $145.3\,cm^2$
    D. $156.6\,cm^2$
19. The diagonals of a rhombus are 20cm and 24 cm long, calculate the area of the rhombus.
    A. $480\,cm^2$
    B. $240\,cm^2$
    C. $120\,cm^2$
    D. $165\,cm^2$
20. The area of a parallelogram is $151.2\,cm^2$. If the base length is 13.5 m, find the height of the parallelogram.
    A. 9.2 cm
    B. 10.2 cm
    C. 11.2 cm
    D. 12.2 cm

END OF OBJECTIVE TEST

PART II

Please provide answers to all the questions in this part. Answers to each question should be shown clearly together with rough work in the spaces provided.

1. The diagram below shows window of a school in the shape of a semi-circle mounted on a rectangle.



Calculate, correct to 3 significant figures,

i. The perimeter of the window

ii. The area of the window. $\left[Take\ \pi = \frac{22}{7}\right]$

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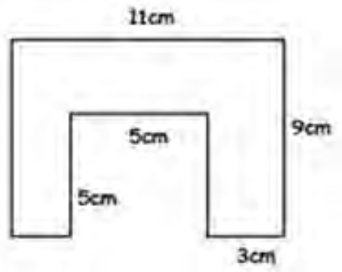
2. The diagram is a composite figure. Find:

i) Perimeter of the figure

ii) area covered by the figure



3. In the diagram, O is the centre of the circle radius r cm and $\angle XOY = 90^\circ$. If the area of the shaded part is $504\,cm^2$, calculate the value of r. $\left[Take\ \pi = \frac{22}{7}\right]$

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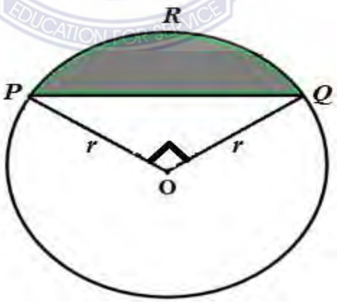


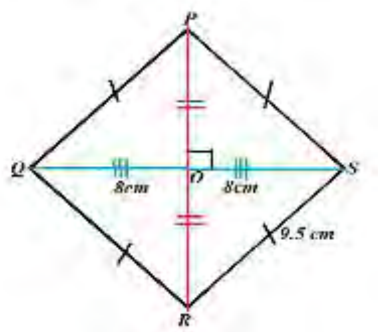
APPENDIX C – MARKING SCHEME (GAT PRE-TEST)

Part I – Objective Test

1. C	11. C
2. B	12. D
3. C	13. A
4. B	14. C
5. B	15. B
6. A	16. A
7. D	17. B
8. B	18. B
9. B	19. A
10. B	20. C

Part II – Theory

Question number	Details	Mark
1 (a)	$d = 8m \Rightarrow r = 4m$	B1 for $r = 4m$
	$P = 2\pi r + 8 + 8$	M1 for the expression
	$P = 2 \times \frac{22}{7} \times 4 + 16$	M1 for substitution
	$p = 25.1429 + 16$ $p = 41.1429m$	M1 for simplifying
	$\Rightarrow perimeter = 41.14m$	A1 for $P = 41.14m$
1 (b)	$A = \pi r^2 + l^2$	M1 for the expression
	$= \left(\frac{22}{7} \times 4^2\right) + 8^2$	M1 for substitution
	$= 50.2857 + 64$	M1 for simplifying
	$= 114.2857m^2$ $\Rightarrow Area = 114.29m^2$	A1 for $\Rightarrow Area = 114.29m^2$ **Total = 9**
2	Let s be the side and P the perimeter	
	$P = 4s$ $\Rightarrow 38 = 4s$	M1 for substitution
	$\Rightarrow s = 9.5cm$	A1 for $s = 9.5cm$
		B1 for diagram

	 By Pythagoras' theorem, $\lvert PQ\rvert^2 = \lvert PO\rvert^2 + \lvert OS\rvert^2$ $\Rightarrow (9.5)^2 = \lvert PO\rvert^2 + 8^2$ $\Rightarrow \lvert PO\rvert^2 = (9.5)^2 - 8^2$ $= 90.25 - 64$ $\Rightarrow \lvert PO\rvert = \sqrt{26.25}$ $= 5.123cm$ Hence $\lvert PR\rvert = 2(5.123) = 10.246cm$ $A = \frac{1}{2}(\lvert PR\rvert \times \lvert QS\rvert)$ $= \frac{1}{2}(10.246 \times 16)$ $= 10.246 \times 8$ $= 81.968cm^2$	M1 for substitution M1 for simplifying M1 for solving A1 for $\lvert PO\rvert = 5.123cm$ A1 for $\lvert PR\rvert = 10.246cm$ M1 for substitution M1 for simplifying A1 for $A = 81.968cm^2$ **Total = 11**
3 (a) **3 (b)**	$A = \frac{\theta}{360} \times \pi r^2$ $= \frac{90}{360} \times \frac{22}{7} \times 9.8^2$ $= 75.46cm^2$ $= 75.5cm^2$ Area (A) of shaded portion is given by: $A = \left(\frac{\theta}{360} \times \pi r^2\right) - \left(\frac{1}{2} r^2 \sin\theta\right)$ $\Rightarrow A = \left(\frac{90}{360} \times \frac{22}{7} \times 9.8^2\right) - \left(\frac{1}{2} \times 9.8^2 \times \sin 90\right)$ $= 75.46 - 48.02$ $= 27.44cm^2$ $= 27.4cm^2$	B1 for formular M1 for substitution M1for simplifying A1 for $A = 75.5cm^2$ B1 for formula or any equivalent expression M1 for substitution (At least one term correct) A1 for both terms correct M1 for simplifying (At least one term correct) A1 for both terms correct A1 for $A = 27.44cm^2$ **Total = 10**

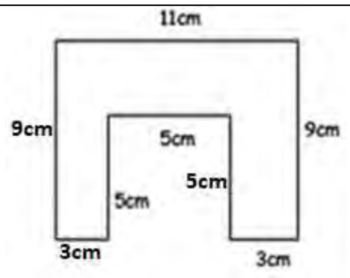
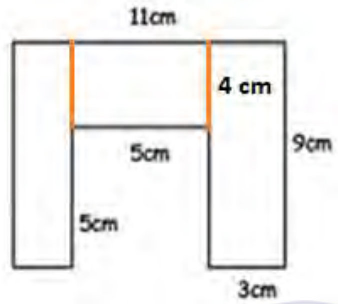
APPENDIX D – MARKING SCHEME (GAT POST-TEST)

Part I: Objective Test

1. D
2. D
3. C
4. A
5. B
6. D
7. A
8. C
9. A
10. B
11. D
12. C
13. C
14. B
15. C
16. A
17. D
18. B
19. B
20. C

Part II – Theory.

Question number	Details	Mark
1 (a)	$d = 14m \Rightarrow r = 7m$ $P = \pi r + 5 + 14 + 5$ $P = \frac{22}{7} \times 7 + 24$ $p = 22 + 24$ $p = 46m$ $\Rightarrow perimeter = 41.14m$	B1 for $r = 4m$ M1 for the expression M1 for substitution M1M1 for simplifying A1 for $P = 41.14m$
1 (b)	$A = \frac{1}{2}\pi r^2 + (l \times w)$ $= \frac{1}{2}\left(\frac{22}{7} \times 7^2\right) + (14 \times 5)$ $= 77 + 70$ $= 147m^2$ $\Rightarrow Area = 114.29m^2$	M1 for the expression M1 for substitution A1 for all correct entries M1 for simplifying A1 for $\Rightarrow Area = 114.29m^2$ **Total = 11 marks**

2		
a)	$P=11+9+3+5+5+5+3+9$ $\Rightarrow P=50cm$	M1 for substitution A1 for all correct entries M1 for simplifying A1 for $P=50cm$
		B1 for diagram (accept similar ones)
b)	$A=(9\times3)+(11\times4)+(9\times3)$ $A=27+44+27$ $A=98cm^2$	M1 for substitution M1 for simplifying (at least one entry correct) A1 for all entries correct M1 for solving A1 for $A=98cm^2$ **Total = 10 marks**
3 (a) **3 (b)**	Area (A) of shaded portion is given by: $A=\left(\frac{\theta}{360}\times\pi r^2\right)-\left(\frac{1}{2}r^2\sin\theta\right)$ $\Rightarrow 504=\left(\frac{90}{360}\times\frac{22}{7}\times r^2\right)-\left(\frac{1}{2}\times r^2\times\sin 90\right)$ $504=\frac{11}{14}r^2-\frac{1}{2}r^2$ $504=\frac{2}{7}r^2$ $2r^2=3528$ $r^2=1764$ $r=42cm$	B1 for formular M1 for substitution A1 for all correct entries M1for simplifying (at least one term correct A1 for all terms correct M1 for solving M1 for $r^2=1764$ M1 for simplifying A1 for $r=42cm$ **Total = 9 marks**

APPENDIX E – STUDENTS' INTERVIEW GUIDE

Name of interview: __________________ **Place of interview**: _____________

Date of interview: _____________________ **Time of Interview**: ______________
Interviewee code: _____________________

Hello, my name is Justice Yawson Mensah from the University of Education, Winneba. The purpose of this interview is to get your views on the mathematics lessons we had, where I integrated ICT in the teaching and learning process. There are no right or wrong or acceptable or unacceptable answers. I would like you to feel comfortable and say what you really think and how you really feel about the questions I will be asking you.

I will be recording our conversation so that I can get all the details but at the same time be able to carry on the conversation with you. I assure you that all your responses and comments will remain confidential. Prior to this interview, you signed a consent form. You are reminded that this interview will not exceed 40 minutes.

If there are no further questions let us get started with the interview

Warm up: Briefly tell me about yourself. In your introduction please tell us who you are, where you from and where you currently live as well anything you feel like telling me about yourself.

1. What can you say about Mathematics as a subject in the curriculum at the SHS?
2. How does your mathematics teacher teach mostly in your class? Does this method make you want to learn mathematics always?
3. Has your mathematics teacher ever employed ICT in teaching you mathematics in your entire school period? Why do you think he has or hasn't?

4. What difference did ICT integration make in your learning process as compared to your teachers' method? Were you motivated by this method of teaching? If yes, how?
5. If you are taught with this method throughout the rest of your time in school, would you have the zeal to study mathematics? Why?
6. Would you prefer that this method of ICT integration is employed by mathematics teachers in your school to teach mathematics? Why?

Thank you for your time. If you have any questions for me, you may ask.

APPENDIX F – MATHEMATCS TEACHERS' INTERVIEW GUIDE

Name of interview: ____________________ **Place of interview**: ______________

Date of interview: _____________________ **Time of Interview**: _____________

Interviewee code: ____________________

Hello, my name is Justice Yawson Mensah from the University of Education, Winneba. The purpose of this interview is to get your views on how ICT integration in teaching mathematics motivates students. There are no right or wrong, acceptable or unacceptable answers. I would like you to feel comfortable and say what you really think and how you really feel about the questions I will be asking you.

I will be recording our conversation so that I can get all the details and at the same time be able to carry on the conversation with you. I assure you that all your responses and comments will remain confidential. Before the interview, please take few minutes to read and sign this consent form. This interview will not exceed 40 minutes.

If there are no further questions let us get started with the interview

Warm up: Briefly tell me about yourself.

1. How long have you been teaching mathematics in total and in this school?
2. What method of teaching do you normally employ in teaching your students? Why?
3. Does this method make your students want to learn mathematics always?
4. Have you ever employed ICT integration as a teaching strategy in teaching mathematics? Why?
5. Does ICT integration motivate students to learn Mathematics at the SHS level? How?
6. All things being equal, would you prefer that this method of teaching is made the conventional method in boosting students' motivation in mathematics?

Thank you for your time. If you have any questions for me, kindly ask.

APPENDIX G – CONSENT FORM

INFORMED CONSENT FORM

You have been selected to participate in this interview. If you are happy to participate then please read, complete and sign the form below.

The purpose of the interview is to gain insight into how ICT integration in teaching geometry motivate SHS students. Our conversations will be recorded to help me accurately capture your views in your own words. The recording will only be heard by me for the purpose of this study. You are assured that your responses will be kept strictly confidential and your name will not be linked with the research materials. For the purpose of analysis, your words may be quoted directly.

Your participation is voluntary and you have the right to withdraw at any time without giving any reason and without there being any negative consequences. In addition, you can choose not to answer any particular question or questions, without any consequences.

By signing this form, I agree that:

- I am voluntarily taking part in this interview.
- I agree that my anonymized data will be kept for future research purposes such as publications related to this study after the completion of the study.
- I have read and understood the purpose of the study

____________________	____________________	____________________
Name of participant	Date	Signature
____________________	____________________	____________________
Researcher's name	Date	Signature

APPENDIX H – LESSON PLANS

LESSON PLAN ONE

Subject: Core Mathematics

Topic: Perimeter of Plane Figures

Duration of lesson: 120 minutes

Target group: SHS 2

Instructor: Justice Yawson Mensah

Relevant Previous Knowledge: Students can identify plane figures and their lengths. Students can find missing lengths using Pythagoras theorem and can also add and multiply real numbers.

Teaching and Learning Materials: Computers, projector, computer images, pair of scissors, and masking tape.

Learning Objectives: By the end of the lesson, the student should be able to:

- Identify and find missing lengths of plane figures
- Calculate the perimeter of given plane figures (Triangle, rectangle, square, trapezium, parallelogram, kite, rhombus and circle).

Teaching and learning activities

- **Introduction:** Researcher reviews students' previous knowledge on identifying plane shapes and Pythagoras theorem. Researcher writes sample questions on the marker board and allows students to do them to test their familiarity and understanding of the concept. Students are shown computer and real life images of plane shapes with the help of an LCD projector.
- **Main lesson**

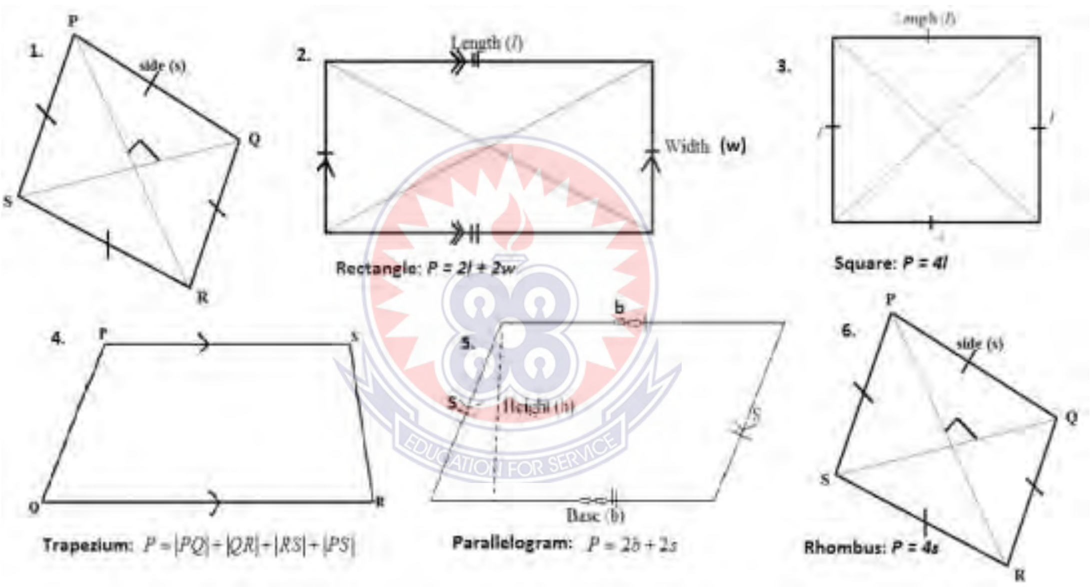
Activity one: Researcher let students brainstorm to come out with the definition of the word "Perimeter". Researcher later clears any doubt on the definition of perimeter by projecting images to show perimeter of plane shapes.

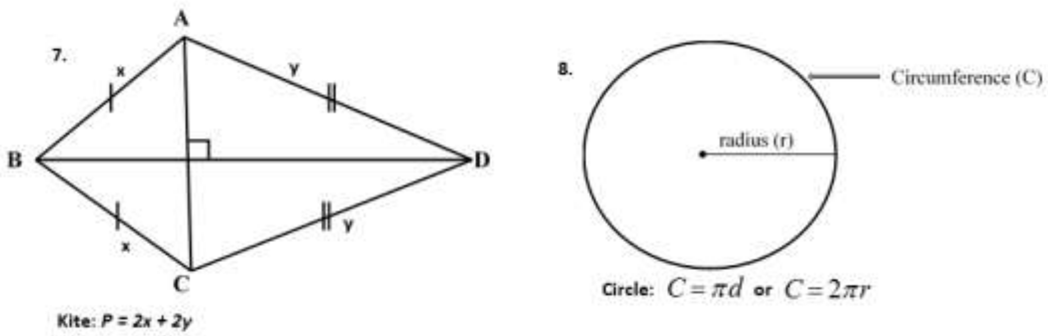
Activity two: With the help of computer applications and PowerPoint presentation (PPT), researcher guides students to find the perimeter of plane figures

Activity three: Researcher puts students in groups of 4 and allow them to explore questions on the concepts learnt on group computers. Researcher goes round to facilitate the discussions and allow students to ask questions for clarification.

- **Conclusion:** Researcher revisits salient points of the lesson with students and instruct students to practice series of questions uploaded on the group computers.

Diagrams and formulas:





LESSON PLAN 2

Subject: Core Mathematics

Topic: Length of an arc, perimeter of sectors and segments.

Duration of lesson: 120 minutes

Target group: SHS 2

Instructor: Justice Yawson Mensah

Relevant Previous Knowledge: Students can find the circumference/perimeter of a circle. Students can also find the perimeters of other plane shapes.

Teaching and Learning Materials: Computers, projector, computer images, PowerPoint presentation, and masking tape.

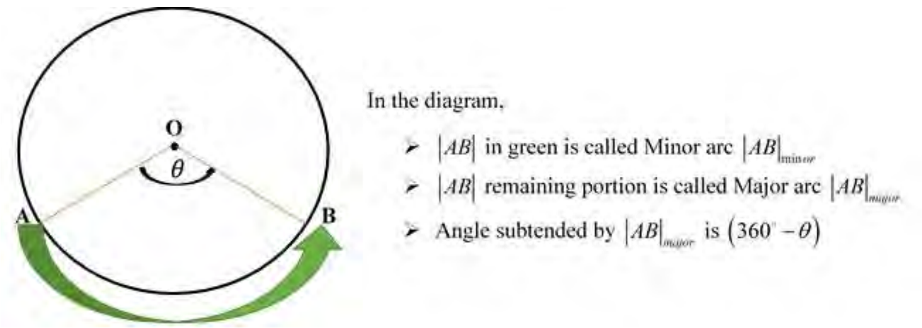
Learning Objectives: By the end of the lesson, the student should be able to:

- Find the length of an arc of a circle.
- Calculate the perimeter of sectors of a circle
- Calculate the perimeter of segments of a circle.

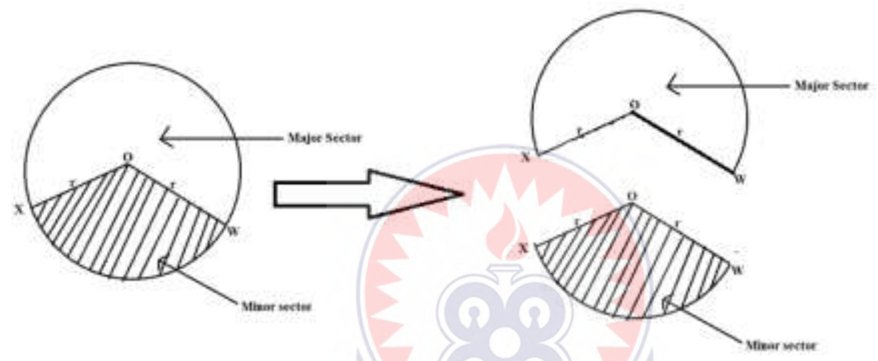
Teaching and learning activities

- **Introduction:** Researcher reviews students' previous knowledge on circumference of a circle. Researcher projects sample questions on the projector screen and allows students to do them to test their familiarity and understanding of the concept. Researcher guides students to identify parts of a circle (Radius, chord, arc, sector and segment).
- **Main lesson**

Activity one: Researcher guide students to identify sectors and segments of a circle and the distance around them. Researcher guide students to deduce a formular to calculate the lengths of arcs of circles as shown in the diagram below;



Activity two: With the help of computer applications, researcher cuts out sectors and segments of circles and guide students to deduce formulas to calculate their perimeters as shown in the following diagrams. Researcher then changes the sizes of sectors and segments of circles and asks students to use the derived formulas to calculate their perimeters.



Activity three: Researcher puts students in groups of 4 and allow them to explore questions on the concepts learnt on group computers. Researcher goes round to facilitate the discussions and allow students to ask questions for clarification.

- **Conclusion**

Researcher revisits salient points of the lesson with students and instruct students to practice series of questions uploaded on the group computers.

Diagrams and formulas:

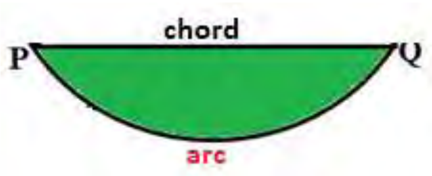
1. $\text{Length of an arc (L)} = \dfrac{\text{angle subtended by the arc } (\theta)}{\text{Sum of angles at a point}} \times \text{The circumference of the circle}$

$$L = \frac{\theta}{360} \times 2\pi r$$

2. The perimeter (P) of a sector of a circle of radius (r) subtending an angle (θ) at the center is

$$P = 2r + \left(\frac{\theta}{360} \times 2\pi r\right)$$

3. The perimeter of a segment is the length of the arc + the length of the cord.



LESSON PLAN 3

Subject: Core Mathematics

Topic: Areas of plane figures.

Duration of lesson: 120 minutes

Target group: SHS 2

Instructor: Justice Yawson Mensah

Relevant Previous Knowledge: Students can identify and draw plane figures. Students can also find lengths using Pythagoras theorem.

Teaching and Learning Materials: Computers, projector, computer images, geometric softwares,

Learning Objectives: By the end of the lesson the student should be able to:

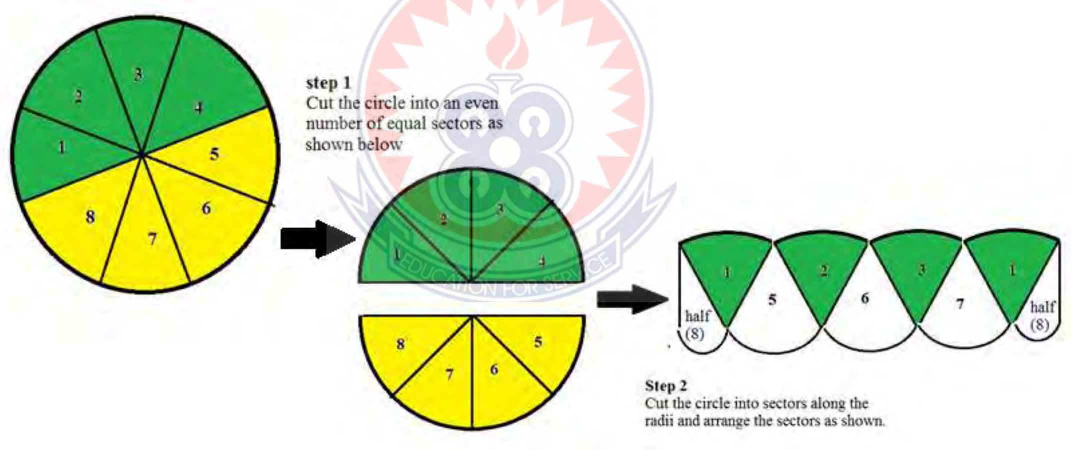
- Calculate the area of quadrilaterals.
- Calculate the area of a circle.

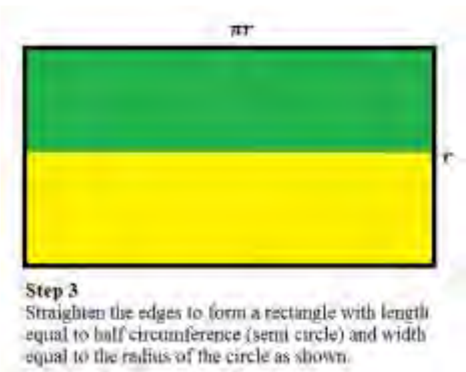
Teaching and learning activities

- **Introduction:** Researcher reviews students' previous knowledge on perimeter and Pythagoras theorem. Researcher guides students to discover the meaning of area of plane figures. Researcher then project some real-life shapes on the projector screen and ask students to talk about their areas.
- **Main lesson**

Activity one: researcher guide students to derive the formulae for areas of quadrilaterals and use them to calculate the areas of given quadrilaterals. Researcher goes through step-by-step procedures with the help of computer applications to guide students deduce the formulas as to calculate the areas of quadrilaterals.

Activity two: With the help of computer applications, researcher transforms a circle into a rectangle and guide students to deduce a formular to calculate the area of a circle as shown in the diagrams below;



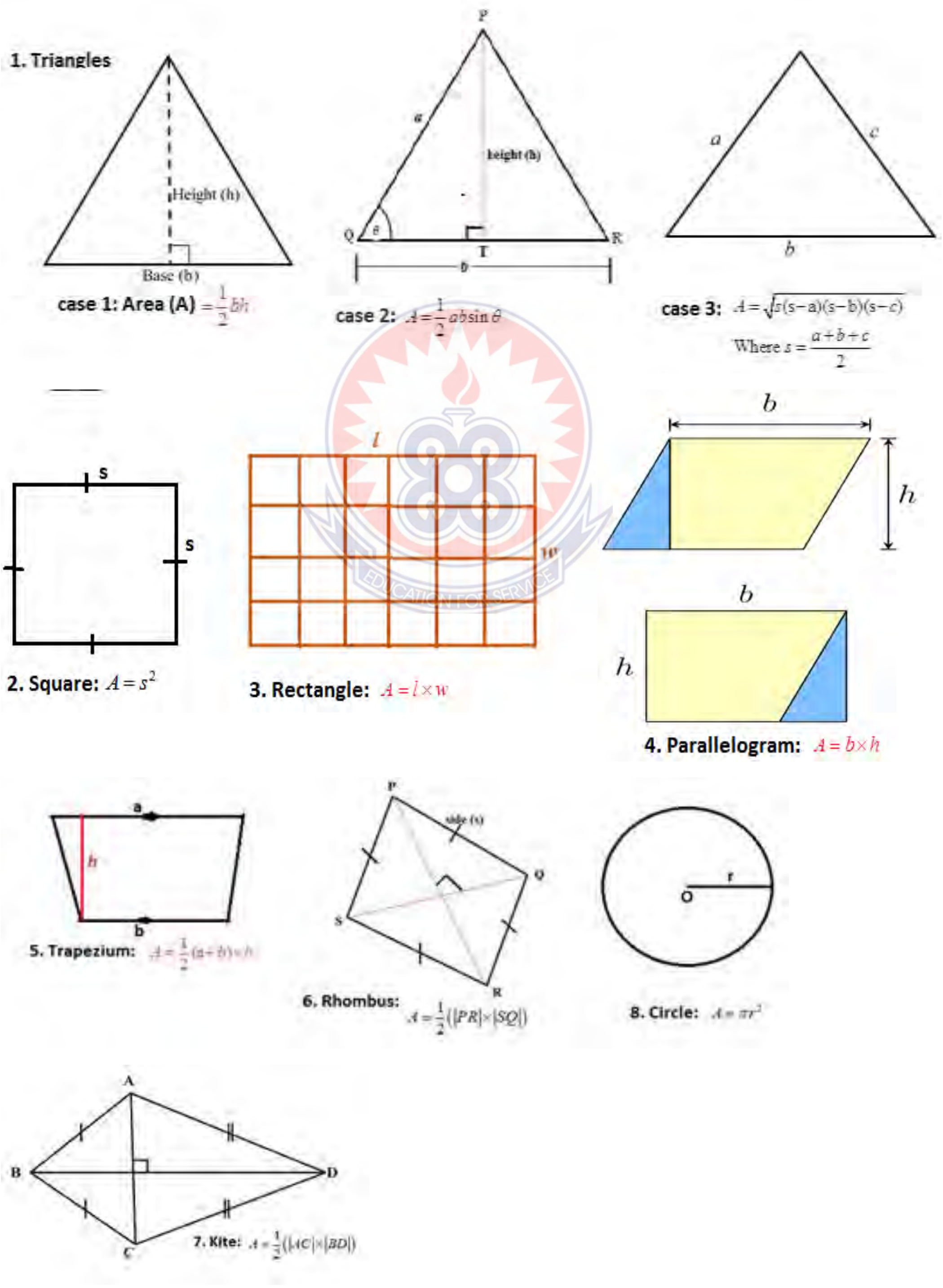


Activity three: Researcher puts students in groups of 4 and allow them to explore questions on the concepts learnt on group computers. Researcher goes round to facilitate the discussions and allow students to ask questions for clarification.

- **Conclusion**

Researcher revisits salient points of the lesson with students and instruct students to practice series of questions uploaded on the group computers.

Diagrams and formulas:



LESSON PLAN 4

Subject: Core Mathematics

Topic: Area of sectors and segments.

Duration of lesson: 120 minutes

Target group: SHS 2

Instructor: Justice Yawson Mensah

Relevant Previous Knowledge: Students can identify sectors and segments of a circle. Students can find the area of circles and triangles.

Teaching and Learning Materials: Computers, projector, cut-outs of cardboards, pair of scissors, and masking tape.

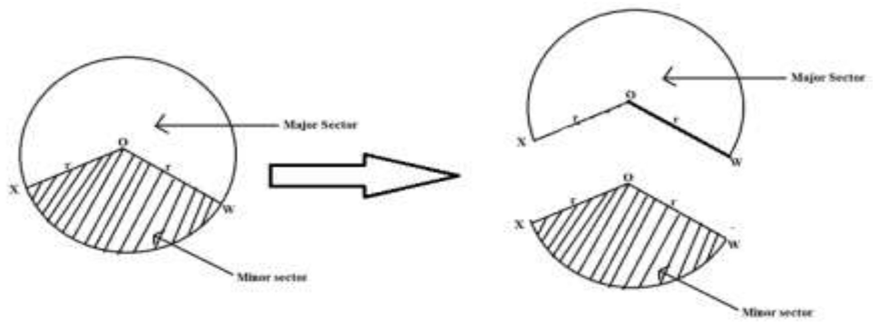
Learning Objectives: By the end of the lesson, the student should be able to:

- Calculate the areas of sectors of a circle
- Calculate the areas of segments of a circle.

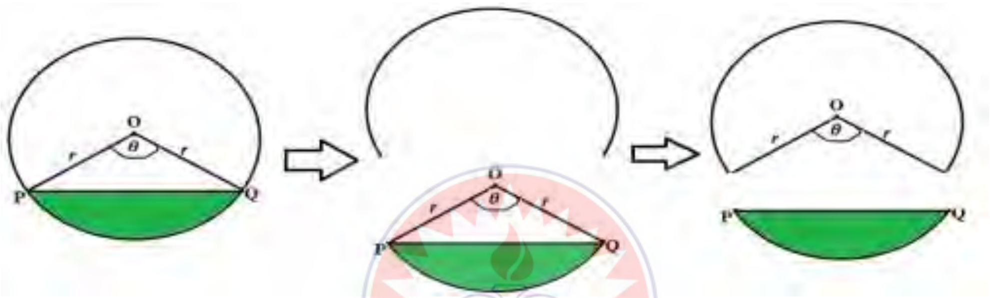
Teaching and learning activities

- **Introduction:** Researcher reviews students' previous knowledge on area a circle. Researcher projects sample questions on the projector screen and allows students to do them to test their familiarity and understanding of the concept before proceeding.
- **Main lesson**

Activity one: With the help of computer applications, researcher cuts out sectors of circles and guide students to deduce formulas to calculate their areas as shown below. Researcher then changes the sizes of angles of the sectors of the circles and let students use the derived formulas to calculate the areas.



Activity two: With the help of computer applications, researcher cuts out segments of circles and guide students to deduce formulas to calculate their areas as shown in the diagram below. Researcher then changes the sizes of segments of circles and let student use the derived formulas to calculate their areas.

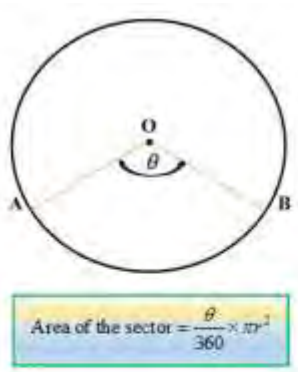


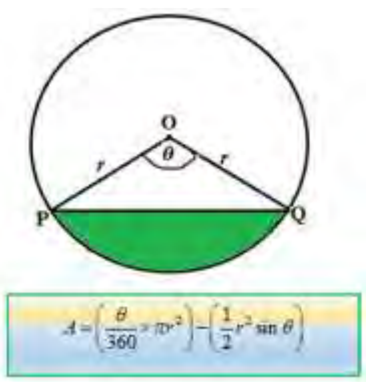
Activity three: Researcher puts students in groups of 4 and allow them to explore questions on the concepts learnt on group computers. Researcher goes round to facilitate the discussions and allow students to ask questions for clarification.

- **Conclusion**

Researcher revisits salient points of the lesson with students and instruct students to practice series of questions uploaded on the group computers.

Diagrams and formulas





LESSON PLAN 5

Subject: Core Mathematics

Topic: Perimeter and area of composite figures.

Duration of lesson: 120 minutes

Target group: SHS 2

Instructor: Justice Yawson Mensah

Relevant Previous Knowledge: Students can calculate the perimeter and area of plane figures. Students can also find the area and perimeter of sectors and segments of circles.

Teaching and Learning Materials: Computers, projector, cut-outs of cardboards, pair of scissors, and masking tape.

Learning Objectives: By the end of the lesson the student should be able to:

- Calculate the areas of composite plane figures
- Calculate the perimeter of composite plane figures.

Teaching and learning activities

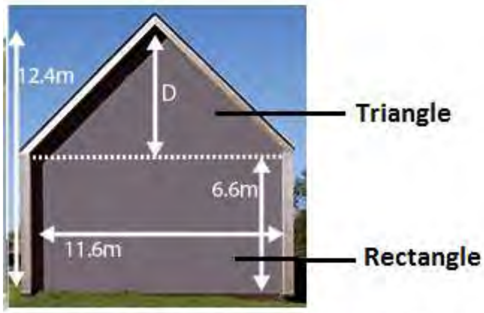
- **Introduction**

Researcher reviews students' previous knowledge on area and perimeter of plane figures, sectors and segments. Researcher projects sample questions on the projector screen and allows students to do them to test their familiarity and understanding of the concept before proceeding.

- **Main lesson**

Activity one: researcher let students brainstorm to come out with the meaning of composite plane figures as two or more plane figures or parts of plane figures combined together to form another plane figure. With the help of projected images, researcher help students identify composite figures in real life as shown in the following examples;

Window of a building made up of a rectangular and a semi-circular portions

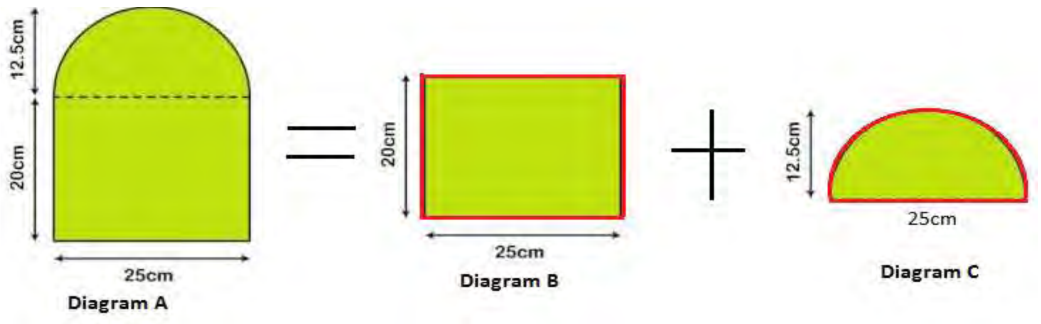


A building plan made up of triangular and rectangular portions

Activity two: With the help of computer applications, researcher separate composite shapes into respective plane shapes and guide students to calculate their areas as the sum of the areas of the individual plane shapes as shown in the example below.

1. The Perimeter of Diagram A = the Perimeter of Diagram B + Perimeter of Diagram C
2. The Area of Diagram A = the Area of Diagram B + Area of diagram C

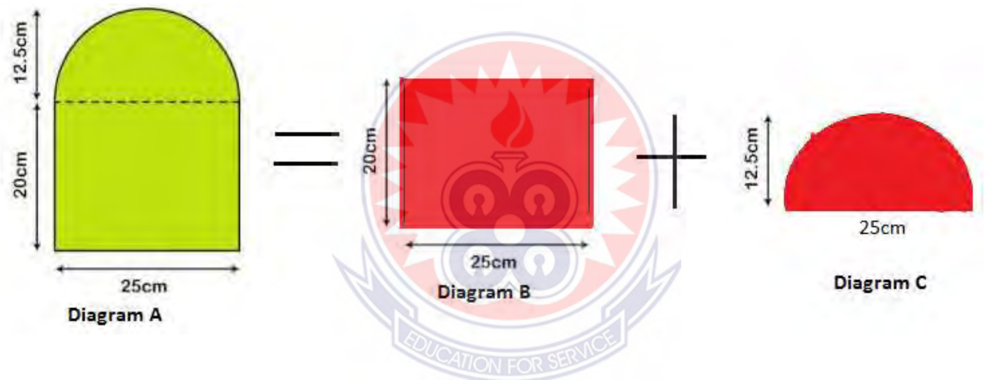
Activity three: With the help of computer applications, researcher trace the distance around composite shapes and guide students to calculate their perimeters as the sum of the distances around it using the examples given in activity two.



Perimeter of Diagram A $= (20 + 25 + 20 + 25) + (\pi r + 25)$

$$= 90 + (\frac{22}{7} \times 12.5 + 25)$$

$$= 90 + \frac{450}{7} = 154.286cm$$



Area of Diagram A $= (25 \times 20) + \left(\frac{\pi r^2}{2}\right)$

$$= 500 + \left(\frac{22}{14} \times 12.5^2\right) = 745.536cm^2.$$

Activity four: Researcher puts students in groups of 4 and allow them to explore questions on the concepts learnt on group computers. Researcher goes round to facilitate the discussions and allow students to ask questions for clarification.

- **Conclusion**

Researcher revisits salient points of the lesson with students and instruct students to practice series of questions uploaded on the group computers.

APPENDIX I – INTRODUCTORY LETTER

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DEPARTMENT OF MATHEMATICS EDUCATION
P. O. Box 25, Winneba, Ghana. Tel: 233- 03323-20999, E-mail: maths @uew.edu.gh

12th February, 2019.

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Dear Sir/Madam

INTRODUCTORY LETTER

Mr. Justice Yawson Mensah (8170110013) is a graduate student who is pursuing an MPhil in Mathematics Education, at the Department of Mathematics Education, University of Education, Winneba. As part of his studies, he has been granted approval by the department's graduate board to undertake a research on **The Effects of Integrating ICT into Mathematics Education on Senior High School Students' Achievement and Motivation.**

We wish to introduce Mr. Mensah to you for any assistance he may require to enable him gather data for his research.

We count on your consent and assistance.

Yours sincerely,

12/02/19

Peter Akayuure
Senior Lecturer
Post-Graduate Coordinator
Department of Mathematics Education
University of Education, Winneba
[Call: 0245309437]