“UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF COOPERATIVE LEARNING ON STUDENTS' PERFORMANCE IN MATHEMATICS IN SIDDIQ SENIOR HIGH SCHOOL

LAMECH OSEI WIREDU

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LAMECH OSEI WIREDU
(200023336)

A thesis submitted to the school of graduate studies in partial fulfilment of the requirement for the award of the degree of Master of Philosophy (Mathematics Education)

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DECLARATION

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Supervisor's Name: Dr. Sylvester Ali Frimpong

Signature:……

Date:……

DEDICATION

I dedicate this work to my better-half, Mrs. Augustina Sarfo and my family members.

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ABSTRACT

The purpose of this study was to determine the effects of Cooperative Learning on Student performance in Mathematics in Siddiq Senior High School because mathematics is perceived as a difficult subject in the school. The study employed pretest-post-test quasi-experimental design involving two intact classes. The instruments for the data collection were standardized pretest and post-test Mathematics questions based on number bases (numeration system) and modular arithmetic. Data were presented and analysed using frequencies, percentages, means and standard deviation. The findings revealed that independent learning style was dominant among the students in studying mathematics. The findings further revealed that applying cooperative learning to the study of mathematics had a positive effect on the performance of students. Another fallout from the study was that the experimental group which received the intervention had a higher increase in mean value from a pre-test value of 0.476 to a post-test value of 0.705. Even though the control group had a slight increase in mean values from 0.343 in the pre-test to 0.533 in the post-test. This data show that cooperative learning has a positive effect on students in Siddiq Senior High School. The study recommends among other things that workshops should be organized by educational bodies to emphasize and enlighten teachers and mathematics educators on the importance of cooperation. Cooperative learning methods would be a viable substitute to traditional method of teaching and learning of mathematics."

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter is made up of the background to the study, statement of the problem, purpose of the study, research questions, research hypothesis, significance of the study, scope/delimitation, organization of the study and the definition of terms.

1.1 Background of the study

The moment system in modern life demands the requirement to have good Mathematical knowledge. Mathematics is important for life and supports all-round personal development (Hodaňová & Nocar. 2016). The body of knowledge and practice known as Mathematics comes from the contribution of thinkers throughout the ages and across the globe. It gives us a way to understand patterns, to quantify relationships, and to predict the future. Mathematics helps us understand the world and we use the world to understand mathematics (Hodaňová & Nocar. 2016).

The world is interconnected. Everyday Mathematics shows these connections and possibilities. For an innovative society and economy, young learners must be exposed to put Mathematical skills to practice. For example, algebra can explain how rapid water becomes contaminated and how many people in a third-world country (e.g., Ghana) drinking from that water might become sickened on a yearly basis. A study of geometry can explain the science behind architecture throughout the world. Statistics and probability can estimate death tolls from earthquakes, conflicts and other calamities around the world. It can also predict profits, how ideas spread, and how previously endangered animals might repopulate (Shah, 2019).

Mathematics is indeed a powerful tool for global understanding and communication. Using it, students can make sense of the world and solve complex and real problems (Shah, 2019). One of the numerous definitions of Mathematics is that mathematics is a way of finding answers to problems; a way of using information, a way of using knowledge of shapes and measures, use our ability to calculate, and most importantly, think for ourselves in seeing and using relationships (Nichols, 2015). Outlining the importance of Mathematics, Nichols (2015), continued by saying that it helps us to measure and make simple calculations. For instance, sick people are asked to take 10ml of blood syrup and are able to take exactly that because of the idea they have in Mathematics. We are able to count and make simple calculations with numbers.

Thanks to Mathematics one is able to count the number of his or her sheep and tell if some are missing. It helps us to know about money and make simple calculations. For example, one is able to notice that the change received after buying say a cup from a shop is not up to what is expected. We are able to recognize shapes because of Mathematics. The school curriculum is nothing without mathematics because it is the lever. It serves as a catalyst for the advancement of all other sciences. Despite its importance, majority of pupils around the world, dislike Mathematics (Gafoor & Kurukkan, 2015). In a paper presented at University Grant Commission (UGC) Sponsored National Seminar on Pedagogy of Teacher Education Trend and Challenges, Mathematics is most liked by only 6% students whereas 88% of students at the High School hates Mathematics (Gafoor & Kurukkan, 2015).

Many students see mathematics as a difficult subject and hence do exhibit little or no love for the subject (Saidu & Bunyamin, 2018; Gafoor & Kurukkan, 2015). This negative perception of students about Mathematics influences their interest and by

extension could directly affect performances in the discipline (Arthur, Asiedu-Addo & Assuah, 2017; Adu-Gyamfi, 2014). Thus, it is no news that Ghanaian students in basic schools are not doing well in science and mathematics to enable them to contribute to national goals and compete in the increasing technological world. Also, results of various national and international assessments indicate the poor state of mathematics education in the country (Anamuah-Mensah, Mereku and Asabere-Ameyaw, 2004; Anamuah-Mensah, Mereku, and Ghartey-Ampiah, 2008; Abreh, Acheaw and Amedahe, 2018). For example, the National Education Assessment (NEA) report (2016) indicated that the performance of P4 and P5 pupils were generally low in English and Mathematics proficiency assessment.

The National Education Assessment (NEA) report (2020) continued by saying that there was no change in performance since 2013, and although the scores for both English and mathematics were low, mathematics continues to present a greater challenge to Ghanaian pupils, in both public and private schools. Moreover, findings from the national EGMA studies in 2013 and 2015 showed that pupils' best performances were on basic Mathematical operations involving rote learning. Understanding and applying Mathematical concepts was observed to be limited. Although there have been some significant improvements in the performance of students in senior high schools, the overall performance in core Mathematics at the West African Senior School Certificate Examination (WASSCE) has been low over the years (Abreh, Acheaw & Amedahe, 2018).

Several factors accounting for this poor performance in Mathematics have been reported by several studies. Factors including learner's interest, difficult in understanding the subject, poor instruction and demand of more time to grasp but

even after which they easily forget what is learnt, students study habits, teaching effectiveness, lack of monitoring of teachers by headmasters, lack of teaching and learning materials, lack of qualified teachers, etc. (Karikari, Achia, Adu & Opoku Kumi, 2020; Butakor & Dziwornu, 2018; Saidu & Bunyamin, 2018; Gafoor & Kurukkan, 2015).

In Siddiq Senior High School, most students are fond of learning on their own. Hardly can you find them learning in groups. But most studies conducted in twentieth century on the relationship between academic achievement and individual learning style supported that pupil performance in different subject areas is related to how individuals learn (Pritchard, 2009). This supports the idea that poor performance of the students of Siddiq Senior High School may be due to their bad learning style. The main rationale for the Core Mathematics Syllabus of Ghana Senior High Schools in accordance with Curriculum Research and Development Division (2010) is to enable all Ghanaian young persons to acquire the Mathematical skills, insights, attitudes and values that they will need to be successful in their chosen careers and daily lives.

Mathematics, in the era of science and technology, is used in almost every area of human activity. Mathematics is therefore a key element of the curriculum (Mahanta & Islam, 2012). Since Mathematics is the key element of the curriculum, here in Ghana, it is required of every student at the Junior High School to attain 8 or better grade before gaining admission into any Senior High School. Also, students at the Senior High School, are to attain C6 or better as a prerequisite to enter any higher or tertiary institution in the country.

It therefore daunts on teachers to whet and encourage students to adopt the best style of learning to help them attain better grades in Mathematics. There are several

teaching and learning approaches that have been found to be helpful for students understanding of Mathematics of which cooperative learning is often cited. Cooperative learning has been defined and explained by many researchers but with a common idea that students should work in groups so they could help each other. For example, Shehzad (2015) defines cooperative learning as a teaching method which involves students in the learning process for understanding and the learning of content of the subject.

Zook (2018) also writes that Cooperative learning is the process of breaking a classroom of students into small groups so they can discover a new concept together and help each other learn. Traditional class activities create a win-lose situation, where one can only succeed if other loose, while cooperative learning is direct opposite to it, here conquest of all is success of all. Cooperative learning has edge over other teaching methods in terms of its effectiveness for improved cognition, social skills and motivation. Two major attributes that have distinguished cooperative learning from traditional learning include interdependence (positive) as well as accountability. That is each member in a group is important, hence all hands-on deck (Slavin, 2011).

Its competence in terms of augmenting academic achievement has been proved by many research studies (McMaster & Fuchs, 2020, Johnson & Johnson, 2019; Nichols, 2015; Winston, 2010). Cooperative learning also improves positive attitudes towards learning, improved social relations in addition to high self-esteem and cohesiveness (McMaster & Fuchs, 2020, Johnson & Johnson, 2019; Nichols, 2015;). Students would end up in jobs that require teamwork someday. Hence developing skills necessary to work with others on projects too difficult and complex for any one

person to do in a reasonable amount of time is necessary (Winston, 2010). Hence the study looked at ways Cooperative learning can improve students of Siddiq Senior High School Mathematical performance.

1.2 Problem Statement

The importance of studying mathematics at the various levels of formal education cannot be overemphasized. This is so because we are constantly engaged in using mathematics to solve everyday problems in our homes, classrooms, offices, businesses, markets, farms, and even on playgrounds. In our classrooms, in particular, students will find it difficult to make progress in their studies if they have problems in mathematics since knowledge in the subject is necessary for them to do well in many other subjects such as accounting, social studies, economics, chemistry, physics, and statistics. Despite these benefits many students see mathematics as a difficult subject and hence do exhibit little or no love for the subject (Saidu & Bunyamin, 2018; Gafoor & Kurukkan, 2015) and this affect their performance.

Several researchers (Karikari, Achia, Adu & Opoku Kumi, 2020; Butakor & Dziwornu, 2018; Saidu & Bunyamin, 2018; Gafoor & Kurukkan, 2015; Rogers and Ford, 1997) have stated that several factors affect students performance in mathematics at the SHS level and these include learner's interest, difficult in understanding the subject, teaching methodology, students learning styles, students attitudes and beliefs, teaching effectiveness, lack of monitoring of teachers by headmasters, lack of teaching and learning materials, lack of qualified teachers, etc.

According to Rogers and Ford (1997) teaching styles and students' learning strategies affect their attitude towards learning mathematics and these have impact on their performance. According to Ragon (2007), a lot of students and even parents are just

concerned about skills and techniques and downplay the importance of their learning styles when it comes to learning. Students want to go directly to memory-improvement, increasing their comprehension, note-taking skills, writing skills, problem-solving skills, and others without understanding that their learning styles play a vital role in acquiring and using each of the skills mentioned. However, the learning styles of students are influenced by instructional styles of the tutor (Ragon, 2007).

In correcting poor learning behaviours of students with respect to mathematics researchers such as Zakaria, et al., (2010); Lavasani &Khandan, (2011) believed that cooperative learning is the key. For example, a study conducted by Edekor & Agbornu, (2020) dubbed Cooperative Learning Strategy and Students Performance in Mathematics in Junior High School in Hohoe Municipality, Ghana revealed that group work arouses students' learning interest, cultivate their exploring ability and creative thinking and improve their team spirit and social communication skills. Again, students performed better using cooperative learning instructional strategy irrespective of their ability level than those students using traditional method. The result of the study also indicated that both the male and female students benefitted equally from the cooperative learning strategy.

Although, there are numerous studies on students' performance in mathematics (Anamuah-Mensah *et al.,* 2004; Roselizawati *et al.,* 2014; Ling *et al.,* 2016; Arthur *et al.,* 2017; Abreh *et al.,* 2018), recent studies have focused on causes of poor performance of students in mathematics (Abreh *et al.,* 2018; Butakor & Dziwornor, 2018; Karikari *et al.,* 2020). Other studies have documented teaching and learning styles and its impact on students' performance (Ajaja & Eravwoke, 2010; Assuah *et*

al., 2017; Ajaja, 2018; Ampadu & Danso, 2018; McMaster & Fuchs, 2020). There exist few studies on cooperative learning (Ajaja & Eravwoke, 2010; Ajaja, 2018; Johnson & Johnson, 2019; McMaster & Fuchs, 2020). However, these studies on cooperative learning above were mostly centred on other subjects such as integrated science and social studies. Furthermore, there was no intervention approach used in the above studies. In addition, by observation, the poor way or style of learning among most of the students in Siddiq Senior High School at Agona Nyakrom is affecting their performance in mathematics. Their performance in Mathematics keeps going down because of their learning behaviour. The Table 1.1 which is an extract from the school's West African Senior School Certificate Examination (WASSCE) performance clearly shows the decline in the percentage of students who pass the exam.

Table 1.1: Performance of Siddiq SHS Students in Core Mathematics in WASSCE (2018 - 2020)

YEARS	PERCENTAGE PASSED (GRADE A1 – C6)
2018	32.73%
2019	29.24%
2020	26.78%

Source: Extract from School's WASSCE data

There is thus, the need to clearly delineate these learning styles of students and use cooperative learning style to improve the performance of the students in mathematics. It is against this background the study sought to determine the effects of Cooperative Learning on Student performance in Mathematics in Siddiq Senior High School.

1.3 The Purpose of the Study

The purpose of this study was to determine the effects of cooperative learning on students' performance in Mathematics in Siddiq Senior High School.

1.4 Research objectives

The study after extensive review of literature arrived at the following research objectives.

1. To determine the essential conditions that will improve performance in mathematics among Siddiq Senior High School students.
2. To investigate the learning styles students in Siddiq Senior High School employ.
3. To determine the extent to which cooperative learning improves the performance of mathematics students of Siddiq Senior High School.

1.5 Research questions

The study adopted the following research questions to help arrive at the needed solution for the problem this study seeks to address.

1. What are the essential conditions that will improve cooperative learning among Siddiq Senior High School students?
2. What learning styles do students in Siddiq Senior High School employ?
3. To what extent does cooperative learning improve the Mathematical knowledge of students of Siddiq Senior High School?

1.6 Hypothesis

The study postulates the following hypothesis based on the second research question.

H_o:there is no statistically significance between the mean performance score of students taught mathematics using cooperative learning strategy and those taught using traditional method.

H_a:there is statistically significance between the mean performance score of students taught mathematics using cooperative learning strategy and those taught using traditional method.

1.7 Significance of the Study

This study would be of benefit to students, teachers, researchers and educational policy makers. The findings from the study would impress on students of Siddiq Senior High the need to study in groups. That learning in a cooperative way has several advantages over individualistic learning.

Again, it is hoped that teachers would be advocates of cooperative learning when they read the outcome of this study. That the findings from this study would serve as a piece of research document to inform and encourage Mathematics teachers to incorporate cooperative learning into the mathematics learning to demystify the subject and to improve the learning and academic performance of students. Cooperative learning is students centred and it enables the teacher to be innovative on how to bring the best out of the students.

Moreover, the findings from the study would serve as spring boards for would be researchers on cooperative learning. Researchers after reading the outcome and the recommendations of this study, would know which area of cooperative learning to conduct further studies on.

Furthermore, this study will expand the existent knowledge on the use of cooperative learning in mathematics. Its successfulness would inform policy makers and curriculum developers to structure the curriculum to reinforce cooperative learning.

1.8 Scope/Delimitation

The researcher delimited the research to Siddiq Senior High School in Agona Nyakrom not because of convenience but because it is the only Secondary School in Agona Nyakrom with very low performance in Mathematics in terms of WASSCE results for some years back. The study only used two intact classes out of the total number of classes of the school. The study only looked at the effects of cooperative learning on senior high schools' performance in mathematics using modulo arithmetic. Moreover, the study only used modulo arithmetic as a topic for data collection. The data collected for the study were only pre-test and post-test items.

1.9 Limitations of the Study

This study was limited by time. Due to the tracking system of education being implemented, duration for setting up, monitoring and testing identified groups for the study were limited. Also, the study was limited to only two classes.

1.10 Organisation of the Study

This study is composed of five chapters. The first chapter focused on the background to the study, the statement of the problem, purpose of the study, objectives of the study, research questions, hypothesis, significance of the study, delimitation of the study, definition of terms, and the organization of the study. The second chapter discusses the relevant literature that relates to the research problem. The third chapter talks about the methodology is about the methodology that was to gather data for the study. The fourth chapter deals with the analysis of the data that was gathered in the

chapter three. The final chapter five, is about the summaries, conclusions and the recommendations.

1.11 Definition of Terms

The study contains some terms that are significant to the study. These terms would be used throughout the study and hence need to be defined to enhance smooth reading of this study by anyone in whose hands the study gets into. Below are the terms which provide basic information for this study and their definitions.

1. **Cooperative Learning:** the instructional use of small groups so that students work together to maximize their own and each other's learning.
2. **Learning Style:** a particular way in which an individual learns.
3. **Social Skills:** Social skills are those specific behaviours performed by all group members which help the group complete the task and like each other when the task is finished."

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter provides a systematic review of the literature and research related to the effects of cooperative learning on students' performance in Mathematics. This chapter consist of overview of cooperative learning and its effects on students' performance in mathematics, brief history of mathematic, theoretical framework, the nature of mathematics, the importance of mathematics, some causes of student's poor performance in mathematics, the concept of cooperative learning and its significance. In retrieving the literature for the study, the researcher utilized Google and Google Scholar, Research gate, databases and search engines.

2.1 The nature and concept of mathematics in education

The root of the term mathematics is in the Greek word mathemata, which was used quite generally in early writings to indicate any subject of instruction or study. As learning advanced, it was found convenient to restrict the scope of this term to particular elds of knowledge (Burton, 2011). Mathematics is the science that deals with the logic of shape, quantity and arrangement. Mathematics is all around us, in everything we do. It is the building block for everything in our daily lives, including mobile devices, architecture (ancient and modern), art, money, engineering and even sport (Oxford languages, 2013).

Discussions of the nature of mathematics date back to the fourth century BC. Among the first major contributors to the discussion were Plato and his student, Aristotle. Plato took the position that the objects of Mathematics had an independent existence and it goes beyond the mind, in the external world. By this Plato drew a demarcation

line between the ideas of the mind and their representations perceived in the world by the senses. In view of this Plato, drew distinctions between arithmetic-the theory of numbers-and logistics-the techniques of computation required by businessmen. In the Republic (1952), Plato posited the study of arithmetic has a positive effect on individuals, as it enables them to reason about abstract numbers. Plato did not recant about his views to the extent he became furious at technicians' use of physical arguments to "prove" results in applied settings.

For Plato, mathematics came to be identical with philosophy for modern thinkers, though they say that it should be studied for the sake of other things (Aristotle, 1952). On the other hand, Aristotle, the student of Plato viewed Mathematics as one of three disciplines into which knowledge could be divided, the physical, the Mathematical, and the theological. Of these, Aristotle saw Mathematics as one which has the quality with respect to forms and local motions, seeking figure, number, and magnitude, and also place, time, and similar things. That Mathematics serves as intersection between the other two, because Mathematics plays an important role in both through the sense and without the senses (Ptolemy, 1952, p. 5).

It should be noted that Aristotle’s view of Mathematics differs from his master, Plato. To Aristotle's Mathematics was not based on a theory of an external, independent, unobservable body of knowledge. Instead, Mathematics was based on real experience, where knowledge is obtained from experimentation, observation, and abstraction. In Aristotle's view, the construction of a Mathematical idea comes through glorification performed by the Mathematician as a result of experience with objects. Thus, Aristotle was of the view that one understands Mathematical relationships through the collection and classification of empirical results derived from experiments and

observations and then by deduction of a system to explain the inherent relationships in the data (Dossey, 1994). The contrasting views about the nature of Mathematics from Plato and Aristotle gave birth to two opposition idea about the nature of Mathematics.

By the Middle Ages, Aristotle's work became known for its contributions to logic and its use in substantiating scientific claims. Aristotle had employed his methods of logical reasoning, those who employed his principles often used them to argue against the derivation of evidence from empirical investigations. In the early 1500s, Francis Bacon separated these two Mathematical schools of thought into pure and mixed Mathematics (Dossey, 1994). Pure Mathematics belongs to sciences that deals with quantity determinate, merely severed from any axioms of natural philosophy. “For many parts of nature can neither be invented with sufficient subtlety, nor demonstrated with sufficient perspicuity, nor accommodated unto use with sufficient dexterity, without the aid and intervening of the mathematics” (Ptolemy, 1952, p. 46).

The struggle between the rationalists and the experimentalists affected all branches of science throughout the 17th and 18th centuries. The German philosopher Immanuel Kant brought the discussion of the nature of Mathematics, most notably the nature of geometry, back in to central focus with his Critique of Pure Reason (Kant, 1952). Kant conceded that all axioms and theorems of Mathematics were truths. He however held the view that the nature of perceptual space was Euclidean and that the contents of Euclidean geometry were a prerequisite understanding of the human mind. This assertion by Kant was in direct opposition to the burgeoning understandings of non-Euclidean geometry. The establishment of the consistency of non-Euclidean geometry in the mid-1800s pave way for other axioms and thus freed Mathematics from the restrictive yoke of a single set of axioms thought to be the only model for the external

world. The existence of consistent non-Euclidean geometries showed the power of man's mind to construct new mathematical structures, free from the bounds of an externally existing, controlling world (Eves, 1981; Kline, 1972, 1985; Korner, 1960). Mathematicians immediately began to apply this new freedom and axiomatic method to the study of mathematics.

New investigations in Mathematics, freed from reliance on experimentation and perception, soon encountered new problems with the appearance of paradoxes in the real number system and the theory of sets. This pave way for three schools of Mathematical thought in the late 19th century and early 20th century, namely the logicism, called the intuitionists and the third formalism. The logicism school was founded by the German mathematician Gottlob Frege in 1884. This school, an outgrowth of the Platonic school, set out to show that ideas of Mathematics could be viewed as a subset of the ideas of logic. That is the contents of Mathematics were the elements of the body of classical Mathematics, its definitions, its postulates, and its theorems. The Mathematical school of thought was founded by Dutch Mathematician L.E.J. Brouwer. Brouwer and his followers did not accept the existence of any idea of classical mathematics unless it could be constructed via a combination of clear inductive steps from first principles.

That is the contents were the theorems that had been constructed from first principles via "valid" patterns of reasoning. The third Mathematical school of thought by the German mathematician David Hilbert. Hilbert's views, like those of Brouwer, were more in line with the Aristotelian tradition than with Platonism. Hilbert did not accept the Kantian notion that the structure of arithmetic and geometry existed as descriptions of a priori knowledge to the same degree that Brouwer did. However, he

did see Mathematics as arising from intuition based on objects that could at least be considered as having concrete representations in the mind. Formalism was grounded in the attempts to characterize Mathematical ideas in terms of formal axiomatic systems. That is Mathematics was made up of the formal axiomatic structures developed to rid classical mathematics of its shortcomings. (Dossey, 1994). The three major schools of thought created in the early 1900s to deal with the paradoxes discovered in the late 19th century advanced the discussion of the nature of mathematics, yet none of them provided a widely adopted foundation for the nature of mathematics. All three of them tended to view the contents of Mathematics as products (ibid).

In view of this Tymoczko (1986) and Hersh (1986) argue that what is needed is a new philosophy of mathematics, one that will serve as a yardstick for the working mathematician and the working mathematics educator. According to Hersh, the working mathematician is not controlled by constant attention to validating every step with an accepted formal argument. Rather, the mathematician proceeds, guided by intuition, in exploring concepts and their interactions. Such a path places the focus on understanding as a guide, not long, formal derivations of carefully quantified results in a formal language. This shift calls for a major change. Mathematics must be accepted as a human activity, an activity not strictly governed by anyone school of thought (logicist, formalist, or constructivist). Such an approach would answer the question of what mathematics is by saying that: Mathematics deals with ideas. Not pencil marks or chalk marks, not physical triangles or physical sets, but ideas (which may be represented or suggested by physical objects).

2.1.1 Role of mathematics in education

Perceptions of the nature and role of mathematics held by our society have a major influence on the development of school mathematics curriculum, instruction, and research. The understanding of different conceptions of mathematics is as important to the development and successful implementation of programs in school mathematics as it is to the conduct and interpretation of research studies. Some see Mathematics as constantly evolving discipline whereas others see Mathematics as statics. For example, the literature of the reform movement in Mathematics and Science education (American Association for the Advancement of Science, 1989; Mathematical Sciences Education Board, 1989, 1990; National Council of Teachers of Mathematics, 1989) portrays mathematics as a dynamic, growing field of study. Other hand Fisher (1990) conceive Mathematics as a static discipline, with a known set of concepts, principles, and skills (Fisher, 1990).

These divergent views of the nature of Mathematics are a precursor to how our society see Mathematics and how they react to its ever-widening influence on our daily lives. The differing views of the nature of mathematics do affects even Mathematics educators' approach to the teaching of the subject to the development of Mathematics by Mathematicians (Brown, 1985; Bush, 1982; Cooney, 1985; Good, Grouws, & Ebmeier, 1983; Kesler, 1985; McGalliard, 1983; Owens, 1987; Thompson, 1984). In relation to this, Steen (1988) writes "Many educated persons, especially scientists and engineers, harbours an image of mathematics as akin to a tree of knowledge: formulas, theorems, and results hang like ripe fruits to be plucked by passing scientists to nourish their theories. Mathematicians, in contrast, see their field as a rapidly growing rain forest, nourished and shaped by forces outside mathematics while contributing to human civilization a rich and ever-changing variety of

intellectual flora and fauna. These differences in perception are due primarily to the steep and harsh terrain of abstract language that separates the mathematical rain forest from the domain of ordinary human activity. These contrasting views of the nature and source of mathematical knowledge have provided a continuum for conceptions of mathematics since the age of the Greeks (Dossey, 1994).

2.1.2 Properties of mathematics

What are the main properties of mathematical activity or mathematical knowledge, as known to all of us from daily experience?

1. Mathematical objects are invented or created by humans.
2. They are created, not arbitrarily, but arise from activity with already existing mathematical objects, and from the needs of science and daily life.
3. Once created, mathematical objects have properties which are well determined, which we may have great difficulty in discovering, but which are possessed independently of our knowledge of them. (Hersh, 1986).

The development and acceptance of a philosophy of mathematics carries with it challenges for mathematics and mathematics education. A philosophy should call for experiences that help mathematician, teacher, and student to experience the invention of mathematics. It should call for experiences that allow for the mathematization, or modelling, of ideas and events. Developing a new philosophy of mathematics requires discussion and communication of alternative views of mathematics to determine a valid and workable characterization of the discipline (Dossey, 1994).

The conception of Mathematics held by the teacher may have a great deal to do with the way in which mathematics is taught. The teacher's view of how teaching should take place in the classroom is strongly based on a teacher's understanding of the

nature of mathematics, not on what he or she believes is the best way to teach (Hersh, 1986). Cooney (1987) used the work of Goffree (1985) and Perry (1970) in his analyses of the nature of mathematics portrayed in classrooms and concluded that school Mathematics is bound up in a formal and external view of Mathematics. Goffree (1985) presented a model for the way textbooks are developed and how teachers might employ them in the classroom to portray the nature of mathematics. The four textbook models were

(a) the mechanistic,

(b) the structuralist,

(c) the empiricist, and

(d) the realistic or applied.

Each of these methods of textbook development portrays a view of the nature of mathematics. Goffree (1985) then crossed these textual characteristics with three ways in which teachers employ textbooks in the classroom:

Instrumental use- The teacher uses the textbook as an instrument, following its sequence and using its suggestions for dealing with the content.

Subjective use-The teacher uses the textbook as a guide, but provides a constructive overview of the materials, followed by a further discussion of the concepts/principles/procedures based on the teachers' experience.

Fundamental use-At this level, the curriculum is developed from an or constructivist viewpoint. This approach is concerned with both the content and pedagogy involved in mathematics. (p.'26) and Hersh argue that what is needed is a new philosophy of Mathematics, one that will serve as a basis for the working mathematician and the working mathematics educator. The reaction of students is a strong factor influencing a teacher's portrayal of the nature of mathematics in class. Brown (1985) and Cooney

(1985) studied the reactions of a first-year teacher in the classroom. The teacher entered the classroom with an orientation that reflected both multiplicity and relativistic characteristics. He attempted to initiate a classroom style involving a good deal of problem solving and student activities aimed at providing a strong foundation for student learning. The students found these approaches threatening and their reactions led to his eventual return to a presenting mode. Cooney (1987) concludes that he suspects that students gravitate toward a mechanistic curriculum and appreciate teachers whose interpretations of the text are quite predictable. If you believe the contrary, listen carefully to the negotiations that take place between students and teacher when test time arrives.

The focus on Mathematics education and the growth of research in Mathematics education in the late 1970s and the 1980s reflects a renewed interest in the philosophy of mathematics and its relation to learning and teaching. At least five conceptions of mathematics can be identified in mathematics education literature (Sowder, 1989). These conceptions include two groups of studies from the external (Platonic) view of mathematics. The remaining three groups of studies take a more internal (Aristotelian) view.

The work of the first group of researchers adopting the external view focuses on assisting teachers and schools to be more successful in conveying this knowledge to children. Their work view Mathematics as relatively fixed, static view of mathematics. Their work most commonly takes a look at the actions and instructional methods being employed by the teacher instead of the mathematics being taught or the methodology in use (Dossey, 1994). The second group of researchers adopting the external view have a more dynamic view of Mathematics, but they focus on adjusting

the curriculum to reflect this growth of the discipline and to see how students acquire knowledge of the related content and skills.

The remaining three conceptions of mathematics found in Mathematics education research focus on Mathematics as a personally constructed, or internal, set of knowledge. In the first of these, Mathematics is viewed as a process. Knowing Mathematics is equated with doing mathematics. Research in this tradition focuses on examining the features of a given context that promotes the doing.

A second personal, or internal, conceptualization of Mathematics is based on the description of Mathematical activities in terms of psychological models employing cognitive procedures and schemata.

The third internal conception of mathematics that surfaces in mathematics education research is one that views mathematics knowledge as resulting from social interactions. Here the learning of mathematics is the acquiring of relevant facts, concepts, principles, and skills as a result of social interactions that rely heavily on context.

2.2 Essential Conditions that will Improve Cooperative Learning among SHS Students

There is hue and cry year after year in Ghana every time the results from the Basic Education Certificate Examinations (BECE) and The West African Senior Secondary School Certificate Examinations (WASSCE) are published. The mass media, the educationist, and people from all walks of life all share in the debate. The most talk about subject that always dominate the discussion is the poor performance of Mathematics. This suggest that teachers, students, parents, and everyone is worried

about the failure of students in Mathematics. The performance of the Ghanaian students in Mathematics have not been encouraging and trends continues. For instance, the National Education Assessment (NEA) administered in July 2013 by UNICEF in collaboration with the Government of Ghana through the Ministry of Education has shown not only that, children in Ghana have struggled to read, but also that performance in Mathematics has lagged behind grade expectations, with the percentages of primary school pupils (P2, P3 and P6) achieving proficiency in Mathematics falling below 20% (Ministry of Education, 2013). Similar results were reported in the 2016 Ghana National Education Assessment (Ministry of Education, 2016).

Also, there had been a remarkable drop in the mathematics performance of some Ghanaian students over the last decade (2012 to 2022) in national and international large-scale assessments such as Basic School Certificate Examinations (BECE); West Africa Senior School Certificate Examinations (WASSCE); and the Trends in International Mathematics and Science Study (TIMSS) (Anamuah-Mensah et al., 2004; Burt, 2017; Butakor, 2016). Specifically, over thirty-four public Junior High schools (JHS) recorded 0% pass rate in mathematics subject in the 2008 and 2010 BECEs. Several factors to the bane of this phenomena (Anamuah-Mensah et al., 2004).

2.2.1 School Essential Conditions

Teaching and learning materials/ resources such as books, stationery, furniture, equipment and recreational facilities are invaluable to effective education. Provision of these resources have direct variation on students' performance because they are aiding that boost. When teaching learning materials are available and teachers employ

them in their lesson delivery, it enhances the effectiveness of the teachers' lesson delivery. To Durlak, Weissberg, Dymnicki, Taylor, and Schellinger, (2011), teaching materials is a generic term that is used to describe the resources teachers use to deliver instruction and it can have good effect on students learning and improve students' achievement. Teaching and learning materials (TLMs) are important because they can significantly increase student achievement by supporting student learning. TLMs come in many shapes and sizes, however their primary characteristic they bear is the ability to support students learning Cohen et al. (2009). Moreover, TLMs add important dimension to lesson planning and delivery of instruction and acts as a guide for both the teacher and students. Teaching and learning materials can assist teachers in meeting every student learning needs. In this way, the teacher becomes a tailor who sews to fit every individual according to their body size. In a similar vein, differentiation of instruction/curriculum is the tailoring of lesson and instruction to meet the different learning styles and capacities within the classroom (Basal, 2015).

Some researchers have called on the need for teachers to be resourceful and are also encouraged to improvise by searching for necessary instructional materials through local means to complement or replace the standard ones (Agudzeamegah, 2014). This means that teaching and learning materials plays a vital role in teaching in our schools and helps especially in teaching and learning of difficult concepts and lessons. In spite of the benefits TLMs brings to lesson delivery however, in Ghana, most schools lack basic resources such as textbooks, syllabus and other resources needed for teaching and learning of mathematics (Okyerefo, Fiaveh, and Lamptey, 2011). Another school factor contributing to the downward spiral in the performance of Mathematics in the Ghana, has been attributed to class size. The surge in enrolment in the Ghanaian schools has not come along with increased in classrooms in most cases. This has

created large class sizes in our schools. Large class size has also been identified as determinants of academic performance in Mathematics.

Studies have indicated that class size, whether large or small can better or derail academic performance. For example, Kraft (2003) conducted a study of the ideal class size and its effect in teaching and learning in Ghana. The findings from the study indicated that the ideal class size should be 40 or less and that anything above 40 is not good. The study concluded by saying that, class sizes above 40 have negative effects on students' achievement. Again, the way Ghanaian Mathematics school curriculum is a designed contributes to the discourse. There is too much emphasis on computational skills than problem-solving. For example, Anamuah-Mensah et al. (2004) attributed the poor performance of Ghanaian junior high school students (JHS 2) in the Trends in International Mathematics and Science Study (TIMSS) in 2003 to the inability of teachers to fully cover the mathematics curriculum content domains of number concepts, algebra, measurement, geometry, and data management. They also opined that the national Mathematics curriculum puts an undue emphasis on number concepts or computational skills, knowledge of facts and procedures to the neglect of problem-solving.

Aside, the mathematics syllabus is overloaded with content and the time frame is small. Kraft (2003) agreed that the syllabus shows evidence of overloading of content to be taught in each grade level at the basic school in Ghana. In view of the fact that the time frame is short, many teachers are not able to complete the syllabus as well as the reading text assigned to each year. There is always an overlap. The teacher at the next grade level start teaching the topics that pertains to that level although the students did not exhaust and master the lessons for the previous grade level. That

leaves a knowledge gap with no one to fill. Kraft (2003) described this situation and problem created by attributing it to the overload of contents in textbooks. This situation results in poor academic of students in mathematics.

School climate comprising of variables such as classroom management, discipline, and leadership styles exhibited by the school heads also influenced students' academic performance (Lee and Shute, 2010). This means it is imperative for heads of schools to use proper leadership skills to garner support of the staff members. It is not a paradox, students performed better in schools where the climate is positive and vice versa (Lubienski, Lubienski, and Crane, 2008). According to Mankoe (2002), is key in the education enterprise as it focuses on six areas of education such as administration, curriculum, instruction, human relations, management and leadership. Effective supervision improves the quality of teaching and learning in the classroom.

Okyerefo, et al. (2011) believed that some heads and teachers of public schools in Ghana, have a very bad attitude and this does not augur well for teaching and learning. Thus, making students in such schools to suffer academically. Some teachers absent themselves, and some even leave the classroom at will because there is insufficient supervision by circuit supervisors. Effective supervision would curve teacher absenteeism as well as teachers taking French leave in the classrooms. This would not only improve teaching in the schools but will also help in covering the contents in the syllabus. Thus, students who have bad attitude towards school and learning would be challenged to change their attitudes toward school and learning.

2.2.2 Teacher Essential Conditions

In education enterprise, the teacher is like a driver who drives passengers to their various destinations in order for them to engage in various activities for the benefits of themselves, their family and the nation at large. The competency level of a teacher and as well as the skills can have a positive or a negative effect on students' performance. Commenting on this, Agyeman (2005), reported that a teacher who does not have both the academic and the professional teacher qualification would automatically have a negative influence on the teaching and learning of his/her subject or area of specialization. In the Ghana education system, some good percentage pupils are in private Primary and Junior High schools.

Unfortunately, a good number of teachers in these schools are Senior High School graduates who had been recruited as pupil teachers to teach. Even the trained teachers in the public schools leaves much to be desired. According to Oduro and Macbeth (2003) almost 50% of teachers at the senior and Junior Secondary level are not professionally trained as Mathematics teachers. More so they are reluctant to go digital, that is to teach with ill-prepared to teach Mathematics with modern technology. Some of these pupil teachers themselves have problems with Mathematics. They lack the requisite skills and methods of teaching Mathematics. They often resort to the crude method and examples from textbook to teach their students. Students of such teachers do not perform better as compared those taught with qualified professional teachers (Oduro and Macbeth, 2003).

Lack of motivation that stems from unfavourable conditions also affect teachers' delivery. It is a well-known fact that teachers at the basic level (from primary to senor high) are poorly remunerated in this country. That means that teachers should look for

alternative livelihoods to augment their income. The effect is that their will and level and commitment to teach will wane. Besides some teachers teach in very dilapidated classrooms whose floors are pitted with holes. In fact, some schools cannot continue at the onset of rains. Agyemang (2005) was of the view even if a teacher is academically and professionally qualified, but works under unfavourable conditions of service, his/her dedication to work would be less and hence low productive than a teacher who is unqualified but works under favourable conditions of service. We should never forget that motivation is a lifeline to every organization including education. Motivation is behaviour that is linked to genuine interest, determination, and commitment, and is related to academic achievement (Sekreter and Doghonadze, 2016).

Motivation can arouse teacher or, students the desire to teach or learn (Farr and Riordan, 2015). In view of this, teacher's enthusiasm, self-determination or self-efficacy has been shown to have an impact on teacher behaviour which in turn impacts on learner's motivation and achievement (Sahakyan, Lamb, and Chambers, 2018). Motivated teachers are more open-minded and are flexible to views on changes in the educational system (Abós, Sevil, Martín-Albo, Aibar, and García-González, 2018). Specifically, motivated teachers exhibit positive dispositions and personality provide more engaging classroom lessons; apply variety of instruction techniques; and build positive relationships with their students (Sekreter and Doghonadze, 2016). Asamoah (2009), stated that the key to improving performance is motivation, and for this reason employers need to understand what motivates their employees.

Mathematics teacher motivation has not been widely instituted in Ghana making teachers not to deliver to their best of abilities (Asamoah, 2009). Teachers with positive attitude towards Mathematics are most likely to implant into student's positive attitude towards Mathematics (Afif, Ulfatin, Kusmintardjo, and Imron, 2017). Research has shown that the attitude of some teachers to their job is reflected in their poor attendance to lesson, lateness to school, bad remarks about student's performance that could damage their self-esteem, and poor methods of teaching which eventually affect students' academic performance (Harris and Bourne, 2017). Evidence has shown that a teachers' enthusiasm has positive effects on their students as such students are daring and better determined in life (Keighren, Crampton, Ginn, Kirsch, Kobayashi, Naylor and Seemann, 2017). Teachers attitude towards Mathematics intrinsically motivates students to learn the subject and perform better (Zee and Koomen, 2016). In Ghana, most teachers do not see Mathematics as a profession, as a result they do not see the need to do research into new and innovative ways of teaching and learning. So, they use the same method throughout the years thereby producing the same outcome year after year (Butakor & Dziwornu, 2018). Teachers' professionalism can have direct or indirect impact on students' performance. Oduro and Macbeth (2003) asserts that almost 50% of teachers at the Senior and Junior Secondary level are not professionally trained as Mathematics teachers.

In addition, most basic education teachers are reluctant to go digital, that is to teach Mathematics using modern technology. The implication is that a teacher qualification plus area of specialty do exerts influence on what the teacher can cover and what the students can learn. A good teacher must have both knowledge in his/her subject area together with some considerable knowledge in some other fields together with the

pedagogy. To Stephenson (2018), pedagogical content knowledge is knowing how to present the same content in a variety of ways that will engender students understanding or to promote learning. Ironically, most teachers including Mathematics teachers lack the pedagogical skills needed to make their students to think Mathematically. Also, Hibbard (2017) thinks that pedagogical knowledge is generic knowledge about teaching and comprises areas such as classroom management (Hibbard, 2017). It therefore beholds on teachers to have both contents and the pedagogy since both work hand in hand.

2.2.3 Student's Essential Conditions

All humans have intelligence and that affects how we perform academically or any field of human endeavour (Nichols and Sutton, 2013). That notwithstanding, every student like every human is unique and have different learning styles which stems from differences in ability. The four styles described in the Honey-Mumford Model are (1) activists (2) reflectors (3) theorists and (4) pragmatists. Activists prefer to learn experientially, that is by doing rather than, for example, by reading or listening. They thrive on novelty, and will give anything a try.

They like to immerse themselves in a wide range of experiences and activities and like to work in groups so that ideas can be shared and ideas tested. They like to get on with things, so they are not interested in planning. Activists are bored by repetition, and are most often open-minded and enthusiastic. Reflectors stand back and observe. They like to collect as much information as possible before making any decisions; they are always keen to 'look before they leap'. They prefer to look at the big picture, including previous experiences and the perspectives of others (Pritchard, 2009).

The strength of reflectors is their painstaking data collection and its subsequent analysis, which will take place before any conclusion is reached. Reflectors are slow to make up their minds, but when they do, their decisions are based on sound consideration of both their own knowledge and opinions, and on what they have taken in when watching and listening to the thoughts and ideas of others. Theorists like to adapt and integrate all of their observations into frameworks, so that they are able to see how one observation is related to other observations. Theorists work towards adding new learning into existing frameworks by questioning and assessing the possible ways that new information might fit into their existing frameworks of understanding. They have tidy and well-organized minds. They sometimes cannot relax until they get to the bottom of the situation in question and are able to explain their observations in basic terms. Theorists are uncomfortable with anything subjective or ambiguous. Theorists are usually sound in their approach to problem-solving, taking a logical, one-step-at-a-time approach. Pragmatists are keen to seek out and make use of new ideas.

Pragmatists look for the practical implications of any new ideas or theories before making a judgement on their value. They will take the view that if something works, all is well and good, but if it does not work, there is little point in spending time on the analysis of its failure. A strength of pragmatists is that they are confident in their use of new ideas and will incorporate them into their thinking. Pragmatists are most at home in problem-solving situations. In view of this, a good teacher ought to know his/her students well and tailor his/her teaching style to encapsulate all students. Low ability students perform poorly in school and this affects their self-esteem. Nevertheless, it has also been observed that intelligent students normally help the low achievers to thrive by helping them to improve their grades and enhance their

confidence (Nichols and Sutton, 2013). In view of this Nichols and Sutton (2013) suggested that teachers need to establish good rapport with their students. This would enable them to know their students learning needs so as to channel energy and attention to those who need most to enhance performance.

Attitude influence performance, therefore, students' attitude toward Mathematics will determine the effort they will put in studying Mathematics and developing Mathematical skills. Commenting on this, Akey (2006) was of the view that students' beliefs about their capabilities and their quest for success in school has direct link with their level of engagement, together with the emotional stress that goes with it. So, attitude do affect what effort a student is willing to put in the mathematical learning process. It is incumbent on Mathematics teacher to strive to develop their students' interest in Mathematics for good performance. Mathematics phobia and anxiety run through adult and young people as well. This creates another obstacle to Mathematics performance. To correct this, Mathematics teachers must strive to give more homework to their students. According to Engine-Demir (2009) regardless of intelligence, students who spend more time on assignments and homework improve their grades. The amount of time students invests in homework and other related activities have also been found to be strongly related to motivation (Butakor, 2016; Butakor et al., 2017).

Esty (2005), stated that "homework bore a positive relationship with learning outcomes when it is relevant to learning objectives, assigned regularly in reasonable amounts, well explained, motivational and collected and reviewed during class time and used as an occasion for feedback to students." Homework is in reality an interaction between school and the home, and an essential ingredient of the

educational process when measuring academic achievement (Esty, 2005). Students' absenteeism is another reason why students perform badly in Mathematics. Some do so for various reasons. For some they have to work on a part time basis to raise money for their upkeep. Skipping classes has a negative toll on students as it affects their performance (Oduro and Macbeth, 2003). Furthermore, some students believe that their success or failure in life would not depend on schooling as there are so many crude ways of making it in life (Tella and Tella, 2010).

2.2.4 Parent Essential Conditions

Charity, they say start from home. The home is one of the agents of socialization. It is the home that each person learns how to say the first words. No wonder the saying, there is no place like home. Okyerefo et al. (2011), observed that the home plays diverse roles in the facilitation of academic performance of students at school. The main role a home plays by parents, with support from other significant household members such as siblings, uncles, aunts among others is to help shape and bring an individual to be responsible adult. Different parenting styles differ and this has created different personalities. In a contemporary society where both mother and father have all entered into the world of work, parents have limited time to interact with their children. For example, some studies have shown that parents spend less time with their children between the ages of six and ten years because they are then normally at school (Okyerefo, et al., 2011).

Level of education and socio-economic which comprise of parents' level of education, occupation and income level all determine home environment (Jeynes, 2002). Socio-economic status has been identified as major determinants of a student's academic performance. For instance, children of parents who are able to provide educational

materials such as Mathematics textbook, and are able to assist their children homework do better in Mathematics than their counterparts (Stipek, Franke, Clements, Farran, and Coburn, 2017). Some parents struggled in their schooling days in Mathematics and at such have negative perception of Mathematics. In view of that they are not able to assist their children with their homework (Burt, 2017).

A parents' occupation does affect academic performance of students. Students from well resource families are more likely to report to school early and are given the best in terms of educational needs and vice. This causes emotional depression to children in this type of family thereby reducing their zeal to perform well in academics (Sattin-Bajaj, Jennings, Corcoran, Baker-Smith, and Hailey, 2018). The level of education a parent has do affects students' performance. Students whose parents are well educated know the essence of quality education and are able to provide both technical and logistical support to their ward education (Schiller, Khmelkov, and Wang, 2002) The implication is that the other students who are not given what they need for their education would lag behind. For optimal academic performance for their wards, parents must discourage absenteeism in their wards. Students who absent themselves regularly from school have lower achievement and may be penalized on test scores (Barker and Jansen, 2000). Lotz and Lee (1999) indicated that sustained absences may affect retention as it may degenerate into truancy. Their study also revealed that the students who are delinquent often have poor grades or perform bad at school, have spotty attendance and later become school drop outs.

In the commonwealth's public schools, it was estimated that by reducing excessive absenteeism by 25% would enable 22,000 more young students to score above the national average on standardized tests (Applegate, 2003). In addition, research

indicates that regardless of social and economic factors, the schools with higher attendance rates achieved higher test scores (Applegate, 2003). According to Dampson and Dominic (2010) the unrelenting parental courage and determination to persevere despite all odds has a ripple effect on children's attitudes toward education and challenge. There have been studies that has confirmed these factors. For example, a study conducted by Mbugua Komen Kibet, Mungiria Muthaa, Nkonke Chuka (2012) entitled factors Contributing to Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya: A Case of Baringo County. The main purpose of that study was to investigate the factors contributing to the poor performance and to establish the strategies that can be adopted to improve performance in Mathematics by students in secondary schools in Baringo County in Kenya.

The study used a descriptive survey research design. The findings were that the factors that contribute to poor performance include under staffing, inadequate teaching/ learning materials, lack of motivation and poor attitudes by both teachers and students, retrogressive practices. Another study that was conducted on the same subject was by Butakor & Dziwornu (2018) dubbed Teachers' Perceived Causes of Poor Performance in Mathematics by Students in Basic Schools from Ningo Prampram, Ghana. The main contention of the study was to find out the factors that influences poor performance of students in Mathematics in selected Basic Schools in the Ningo Prampram District in Accra, Ghana. The study used a descriptive survey for the design with random and convenient sampling as the sampling procedure to sample 60 teachers for the study. Data was collected through questionnaire and analysed using SPSS version 21 software. The findings revealed that the most highly ranked school environmental factors responsible for student's low academic

performance in mathematics were lack of supervision and monitoring of teachers by head teachers and circuit supervisors, larger class size and lack of teaching and learning materials in school. Similarly, the most highly ranked teacher factor that contributed to student's low academic performance in mathematics was untrained teachers teaching the subject. Also, high level of absenteeism among students and unruly student behaviour were the most highly ranked student's characteristics responsible for their poor performances in mathematics. As it has been established elsewhere in the study, teachers must vary their instruction approaches to meet each of their students learning. One teaching method that has been found to elicit and sustain students' interest in cooperative learning.

2.3 The Concept of Cooperative Learning

Through no fault of theirs, a lot of Mathematics educators' resort to lecture method which results in rote learning and memorization. This method is good because it allows a teacher to cover more contents within a short period of time. Nonetheless, it leaves several students in the lurch as they find it easy to recall thus leading to poor performance in Mathematics. Harbor-Peters (2018), opined the issue of poor performance in Mathematics examinations was due to problem of teaching methods. This has raised concerns with Mathematics educators about the use of traditional methods which does not seem to be working. Hence the clamour calls for a change. Johnson & Johnson (2019) and Slavin (2018) have proposed that cooperative learning promotes good results for students' performance in Mathematics. Cooperative learning is all student's involvement in learning. It is about getting every student involved in the teaching and learning process in order for them to understand the subject contents Slavin (2011).

Akinbobola (2015) defined cooperative learning as a way of learning in which students of different ability levels work together in small groups to achieve a goal. It involves the use of a variety of learning activities to improve the understanding of a topic This indicates that cooperative learning is a broad concept with a range of methods; the key factor being that pupils are placed in small groups and help one another with academic tasks. Similarly, Johnson & Johnson (2019), calls learning by cooperation as working together to accomplish shared goals. Here the key issue is joint working with a shared purpose. Cooperative learning is a teaching strategy that organizes students in small groups so that they can work together to maximize the learning of others. In particular, the cooperative learning approach to education is the place where students are organized in pairs or in small groups to help each other in learning the assigned material (Arbab, 2003; Trowbridge, Bybee & Powel, 2000). Students in a group interact with each other, share ideas and information, seek for additional information and make decisions about their discoveries for the whole class.

There are four basic elements in the cooperative learning strategy. These basic elements include: (1) small groups must be structured for positive independence; (2) there must be face-to-face interactions, (3) individual responsibility and (4) use of interpersonal skills and small groups. It is known that cooperative learning actively involves students in the learning process and seeks to improve the critical thinking, reasoning and problem-solving skills of the learner (Borich, 2015). Jacobson and Baribor (2012) emphasized that group work arouses students' learning interest, cultivate their exploring ability and creative thinking and improve their team spirit and social communication skills. Group work can help students become more active in their learning. When working with peers in a group, students are encouraged to articulate their ideas and question the ideas of others.

According to Simek, Byilar and Kucuk (2013), cooperative learning is a process aimed at facilitating the achievement of a specific end product or objective through people working together in groups. Similarly, Ruel and Bastianns (2003) see cooperative learning as a method of instruction that allows students the independence of the use of mental processes to contribute to knowledge. Naseem and Bano (2013) believe that when students of different cognitive, intellectual and physical levels are exposed to solving a given task, they have the opportunity to interact and work as a team. They say it improves learning attitudes, interpersonal skills and the concept of self. Teacher dependency also decreases. Therefore, the teacher's role changes from providing information to facilitating student learning. Therefore, the teacher remains in the background and becomes a guide, a facilitator, an illuminator or a torch bearer. The tasks of cooperative learning are usually intellectually demanding, creative, open and involve higher-order thinking tasks. Cooperative learning can therefore give weak students the opportunity to learn and achieve the maximum (Ajaj, 2018). Furthermore, cooperative learning involves group work among students, resulting in positive interdependence. Typically, in cooperative learning, academic assignments are structured or divided so that everyone can participate fairly and all students are responsible (Candler, 2014).

2.3.1 Principles of Cooperative Learning

Students can succeed in cooperative learning lest they follow these five basic tenets of cooperative learning. The first basic principle is called Positive Interdependence. Positive interdependence springs from the believe that each person in a group is welcomed and accepted for who he/she is. That is there is unbreakable unity within the group so much so that each member believes that the success or failure of the group depends on each member. In view of this, every member of a group work

together and assists each other in order to complete a given academic task. Every member prepares well or study the learning material. It is all hands-on deck approach to tackling issues. (Johnson & Johnson, 1994). That is each individual depends on the other members of the group. The role of the teacher is to provide reward to the most successful group. This will ginger the other members in other groups to be serious. Individual Accountability is the second basic tenet of cooperative learning. This is the post-mortem analysis of task. That is after each person within a group has completed the assign role/work and the results assessed with the feedback. Then members of the group would know if any of them requires assistance in completing the task. That way each member becomes accountable for their own learning as well as that of their group members.

The third principle of cooperative learning if Face to Face Interaction. This refers basically to the sitting arrangement of group members. In cooperative learning, students are made to sit close to each and facing each other. This helps in better exchange of ideas, or answers. It also boosts the confidence of group members. The role of the teacher is to promote each student to be successful by helping out, guiding and giving support, encouraging and praising them in learning. Interpersonal and Small Group Skills is the last but one principle of cooperative learning. It takes social skills to be able work within a group. Humans are social beings and therefore needs to be taught needed social skills for peaceful coexistence within a society. Students are the legacy of tomorrow and therefore needs to be taught the social skills so as to achieve a higher quality of cooperation. These skills include the ability to instruct others to work together in a group and the ability to speak in a firm but soft voice and manage conflicts. Furthermore, Group Processing is another tenet of cooperative learning. This refers to evaluation rod that group members assess how they fared. It is

the time where they gather and discuss the success chalked, and where they need to improve to achieve the set target and at the same maintaining effective working relationships.

2.3.2 Types of Cooperative Learning Strategies

There are several types of cooperative learning strategies. These include Students Teams – Achievement Division (STAD), Team-Games-Tournaments (TGT), Jigsaw Method, Team Accelerated Instruction (TAI), Group Investigation (GI), Team Assisted Individualization (TAI), Cooperative Learning and Teaching Scripts (CLTS), Cooperative Integrated Reading and Composition (CIRC), Cooperative Learning Structures, and Complex Instruction (Maddinabeita, 2006).

2.3.2.1 Student Teams Achievement Division (STAD)

This the most widely used strategy in which usually small groups of learners with different levels of ability come together and work on a given task to achieve a desire learning goal (Slavin, 1990). It is applicable to many disciplines.

2.3.2.2 Group-Maths-Tournament (GMT)/ Team

This is commonly called the GMT method is a modified version of the TGT method developed by Robert Slavin. Team- Group- Tournament (TGT) uses the same presentations as in STAD, but replaces the test with weekly tournament game which does not use the system of improvement score. It can be used to teach mathematical skills and knowledge.

2.3.2.3 JIGSAW

This is another strategy that was developed by Elliot Aronson and Associates in the early 1970s. In this approach the teacher introduces the topic and the topics sub

sections is divided and shared among the students in groups of five or six called the jigsaw groups. In Jigsaw application, the concept of learning is sub-divided into different segments, and each student is assigned to a sub-topic so as to enable him/her specialize. This makes the students expert in the section assign to them. This leads to the formation of expert group. At the end of the lesson, each group is disbanded and individual within each group solves or answers self-assessment questions independently. The achievement scores of individual members are added up to give the group aggregate scores.

2.3.2.4 Team Assisted Individualisation (TAI)

The TAI method is designed for the learning of mathematics in small heterogeneous groups (usually 2 to 4 students) per group. Each student is given a worksheet or a task to be completed. After completion students would then work in pairs to check each other's worksheet or a task. Students who obtain 80% and above from the worksheet or the task, would be allowed to sit for the final test.

2.3.2.5 Learning Together (LT)

Learning together was developed by David Johnson and Roger Johnson. In this model, students would work on the task in 4 – 6-member heterogeneous groups. Worksheets would then be distributed to each group and required to submit the completed worksheet, for recognition. This would be based on the group's achievement.

2.3.2.6 Group Investigation (GI)

The Group Investigation method also involves small groups of 2-6 students where each group would carry out the cooperative inquiry, discussion, and project. Moreover, it is said to be one of the most student-centred methods as students have

much freedom to choose their topics of interest for investigation, plan and carry it out, present and evaluate the results (Tukur Madu, Nurul Wahida Binti Hj and, Madya Ruzlan, 2018).

2.4 Cooperative Learning and its effects on students' performance in mathematics

A review of the studies on the effects of cooperative learning on student's performance indicated that all researchers made similar findings. Ajaja (2018), Crosby and Owens (2014), Steven and Slavin (2018), Megnin (2020), Webb, Tropper and Fall (1995) found that the cooperative learning is not limited to a particular ability level or sex, but to all who engage in it. Similarly, Glassman (2015) and Johnson, Johnson and Stanne (2020) found that cooperative learning emphasizes status and respect for all members, regardless of gender. More profoundly, the study by Crosby and Owens (2018) found that different cooperative learning strategies can be employed to help low ability students to improve achievement, who had difficulties making success in the traditional classroom. Ajaja and Eravwoke (2010), also reported a non- significant difference in achievement test scores between the male and female students in cooperative learning group. This mean that there was no gap between the performance of male and female in Mathematics after being taught through cooperative learning methods.

Aziz & Hossain (2010) conducted a study in which they compared traditional teaching method against cooperative learning on students' achievement in mathematics in secondary school. Their findings revealed that there was a statistically significant difference in favour of the experimental group. Again Sherman & Thomas (1986) compared the effects of Cooperative Learning on all levels of students: bright,

average, and weak, to see if Cooperative Learning could enhance achievement in mathematics for students. The results of the study indicated that students at all levels were found to retain memory much longer, increase the ability to solve mathematics problem, and develop positive attitude towards learning mathematics and have a higher self-esteem.

Furthermore, Leikin, & Zaslavsky (2013) studied Cooperative Learning in mathematics and they concluded that the experimental group in Cooperative Learning setting enabled a higher level of learning. Equally important was the study conducted by Ajaja & Eravwoke (2010). The study used 2x2x2x2 factorial, Pre-test, Post-test Control Group design which included two groups of males and females; high and low. The recurrent test indicated that learners taught under Cooperative Learning approach earned higher scores in science achievement test than those taught under traditional method of teaching. Again, Zita (2010) conducted research on seventy-two students from four College mathematics classes. The study used a mixed methodology (Quantitative and Qualitative) design. The research showed an improvement in mathematics achievement.

Additionally, Kolawole (2008) studied Comparing Cooperative Learning Strategy and Competitive Learning Strategy in teaching of mathematics at Secondary School level using a sample of 400 learners out of which 240 were boys and 160 girls. The result revealed that Cooperative Learning is more effective than competitive learning method in teaching and learning of mathematics. In a similar vein, research that was conducted by Edekor & Agbornu (2020) entitled Cooperative Learning Strategy and Students Performance in Mathematics in Junior High School in Hohoe Municipality, Ghana. The purpose of the study was to investigate the effect of the cooperative

learning strategy on the academic performance of students in mathematics at Junior High School level. Again, the study specifically wanted to find out whether there would be a difference in the mean performance score between the experimental and non-experimental group.

More so whether there was a difference between the mean score of the males against the females in the experimental group. Using a quasi-experimental group design, the results after the analysis revealed that the mean and standard deviation the group taught mathematics using cooperative learning strategy has a protest mean of 8.26 with a standard deviation of 3.29 while a group taught mathematics using traditional method had a pre-test means of 7.56 with a standard deviation of 1.06. Again, the group taught Mathematics using cooperative learning strategy had a post-test mean of 18.73 with a standard deviation of 7.46 while a group taught using traditional method had a post-test mean of 10.54 with a standard deviation of 2.63. The difference between the pre-test and post-test means of a group taught using cooperative learning strategy was 10.47 while that of a group taught using traditional method was 2.98of pre-test scores of students taught using cooperative learning strategy and those taught with traditional method. The conclusion is that cooperative has positive effects on students' performance.

As to whether there was is difference between the mean performance score of male and female students taught using cooperative learning strategies at Junior High School in Ghana. The results from the analysis shows that the male students taught mathematics using cooperative learning strategy had a pre-test mean of 5.35 with standard deviation of 2.13 and a post-test mean of 16.40 with a standard deviation of 2.89. The difference between the pre-test and post-test means for the male group was

11.05. The female students taught mathematics using cooperative learning strategy has a pre-test man of 5.85 with a standard deviation of 1.69 and a post-test mean of 16.90 with standard deviation of 1.81. The difference between the pre-test and post-test means for female group was 11.05. That means that using cooperative learning strategy, both male and female students improve in their learning of Mathematics. In view of these findings, the study recommended that Mathematics teachers to adopt the cooperative learning strategy in order to improve students' performance, social interaction skills and foster meta-cognition in students.

Moreover, workshops should be organized by educational bodies to emphasize and enlighten teachers and mathematics educators on the importance of the cooperation (ibid). Cooperative learning methods would be a viable substitute to traditional method of teaching and learning of mathematics.

2.5 Learning styles

The term learning style in educational context is often used interchangeably by some researchers to denote cognitive style of learning (see Hayes & Allinson, 1998). But some researchers indicate that the concept learning style is a comprehensive terminology which includes the cognitive learning style, affective style, and physiological style domains (see Terry, 2002; Rayner & Riding, 1997).

Learning styles refer to behavioural and attitudinal factors that stimulate learning in every circumstance (Hayes & Allinson, 1998; Terry, 2002; Dunn, 2000; Rayner & Riding, 1997; Hoover & Marshall, 1998). The interactions between the way students learn and how the teachers teach are largely influenced by different learning styles. Learning style guides and determines our behaviour and how we tackle our daily activities (Hayes & Allinson, 1998; Terry, 2002; Dunn, 2000; Rayner & Riding, 1997;

Hoover & Marshall, 1998). In the processes of learning, learners prefer using different methods of managing, processing, and interacting with information. These methods, processes and preferences are described as Learning Styles (Şirin & Güzel, 2006; Terry, 2002; Rayner & Riding, 1997).

The styles of learning of individuals are significant in the educational enterprise as it relates to how individuals perceive, relate with, and respond to their learning environments bringing out issues regarding students different learning styles. Generally, learning style facilitates the natural pattern of obtaining and making sense of information in the process of learning. There have been many researches on the concept, but there is no consensus regarding its definition; but an important consideration is that individuals have differences in how they learn (James & Gardner, 1995; Terry, 2002; Rayner & Riding, 1997). The learning style of individuals is based on the issues regarding how information is gathered, processed and applied when it is required. Individual differences amongst students often influence both their learning and their academic attainment (Riding, 2005; Terry, 2002; Rayner & Riding, 1997). When students are exposed to a teaching and learning style that corresponds with their learning style, they can potentially achieve high academic success (Felder, Felder, & Dietz, 2002; Rayner & Riding, 1997; Dunn & Griggs, 2000).

2.6 Theoretical framework

The theoretical framework for the study was Vygotsky social constructivism theory. Social constructivism is a learning theory propounded by Lev Vygotsky in 1968. The theory states that language and culture are the frameworks through which humans experience, communicate, and understand reality. According to Vygotsky, language

and culture play essential roles both in human intellectual development and in how humans perceive the world. That is before learning can take place, acquisition of language is a prerequisite. It is language that would serve as a medium through which a learner can interpret and understand through experience within a cultural setting. It is a fact that it takes a group of people to have language and culture to construct cognitive structures, because of that knowledge is not only socially constructed but co-constructed.

The social constructivist believes that knowledge is acquired when students collaborate with other students, teachers and peers. In view of that, Nichols (2015) posited that the level of potential development (academic achievement) hinges on the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. Nichols (2015) sees learning as a social activity where a learner associates himself/herself with other humans like the peers, family members as well as casual acquaintances, including their predecessors. A learner is/will be able to achieve his/her learning objectives lest they have conversation with others, interact and apply knowledge they received.

Vygotsky believed that life long process of development is dependent on social interaction and that social learning actually leads to cognitive development. In other words, no man is an island when it comes to the acquisition of knowledge. We interdepend on each other. Students acquire knowledge under adult's facilitation or through peer collaboration. This according to Vygotsky is called scaffolding. Vygotsky theory provides opportunities for students to collaborate with their teachers and peers in constructing knowledge and understanding. According to Kapur (2018), social construction of knowledge can take place in many ways and at different

settings. It could be achieved through group discussion, cooperative learning, or any instructional interaction in an educational or training institution, social media forum, religious and market places. As students interact with people, the material and immaterial environment, they gain understanding and gather experience which is needed to live successful and functional lives. Social constructivism is also called collaborative learning because it is based on interaction, discussion and sharing among students. This teaching strategy allows for a range of groupings and interactive methods. These may include total class discussions, small group discussions or students working in pairs on given projects or assignments (Akpan, Igwe, Mpamah and Okoro, 2020). Vygotsky's theory has implication for the teacher and the learner as well.

There is a need for Mathematics educators to adopt teaching strategies that would make their students not only develop Mathematical interest but also to bring the best out of them. According to Dorgu (2015), teaching method is/are strategies a teacher uses to deliver his/her subject matter to the learner based on predetermined instructional objectives in order to promote learning in the students. Also, Westwood (2008) opines that teaching method is made up of the principles and methods that teachers use to enable their students to learn. From the assertions made by Dorgu and Westwood, we can infer that the essence of teaching is to employ principles and methods that are permissible to enable students achieve their learning potential. These principles and methods are founded on theories of learning including social constructivism. To Kelly (2012) social constructivism could be applied in the classroom using such instructional methods as case studies, research projects, problem-based learning, brainstorming, collaborative learning / group work, guide discovery learning, simulations among others. The teacher could sometimes divide the

class into groups or pair the students and then guide by prompting, questioning and directing the groups or pairs to discover concepts or gather learning experiences according to the intended objectives (Akpan, Igwe, Mpamah and Okoro, 2020). For activity/group work (collaborative or learning through cooperation), for example, learners are put into small groups of learners working together to achieve an instructional objective. Each learner is assigning a tenable role within the group that may be formal or informal. Learner's converse, interact on what they already know (relevant previous knowledge), what they need to know and how to fish out the information to unravelling the truth (Akpan, Igwe, Mpamah and Okoro, 2020). The role of the teacher is to facilitate the learning process by supporting, guiding, and monitoring. The teachers aim is to build learners' confidence when addressing problems, while also expanding their understanding.

To conclude, social constructivism encourages active participation of students, encourages active participation and interaction among learners, the teacher and other components of the teaching learning process, and boost the development of skill. It also encourages students to develop and use their own initiatives, discourages rote learning and passivity on the part of students. Moreover, it stimulates interest and aids retention, develops critical thinking and problem-solving capacity, promotes individual and cooperative learning in the classroom. Furthermore, it promotes team spirit among students as the work in groups and engenders curiosity on the part of learners through the use of activity-based teaching methods employed by the teacher (Akpan et, al. 2020).

There are several studies that have used social constructivism theory and the results have been positive. For example, a study conducted by Aliki, Menon, Boruff, Ana and Sara (2014) dubbed application of social constructivism learning theory in knowledge translation for healthcare professional. The main contention for the research was that lots of health worker do not adhere to scientific evidence-based practices when giving care to their patients. This is because there is a gap between what is known to improve patient's outcomes and what is used in daily practices. In view of that there was the need to develop effective knowledge translation (KT) for the health workers in order to close the between knowledge-of-practice gap. The study employed social constructivism learning theory because according to researchers, social constructivism approaches to the science of KT has the potential to support researchers in examining how learning in the clinician context occurs and how new knowledge is created, disseminated, exchanged and use to inform practice. One of the key findings was that constructed knowledge or knowledge that comes from a collaborative process among stakeholders in the clinical setting can and should be considered as authentic sources together with evidence generated from research (ibid).

Another study conducted by Shah (2019) on the use of social constructivist approach to learning social study classroom. The major aim of the study was to address the question do we have any alternative of deficit model of teaching learning? This is because the researcher observed that teachers teaching social studies did not follow teaching activities and methods as enshrined in the curriculum mainly because curriculum and teacher's guide were out of access of the teachers. Besides, teaching learning methods developed in the curriculum and teachers' guides were not easily understandable and applicable. The study went further to observe that textbooks seemed to be the only teaching aid available to both the students and the teacher. That

created a lacuna between the teaching methods prescribed in the curriculum and the teaching strategies adopted by the primary level Social Studies teachers.

To address this problem, Shah (2019) adopted the theoretical underpinnings of socio-cultural approach to learning and designed and carried out constructivist teaching learning setting for teaching social studies. Using a qualitative method for the data collection, the study revealed after the analysis that constructivists pedagogic settings help to develop and sustain a culture of inquiry in the classroom where the strong interface between students' everyday knowledge and school knowledge take place. Rather than relying on teacher's unquestionable authority, students in these pedagogic settings propose and defend their own views. The students also respond thoughtfully to views of others. The whole class benefits from sum of cognition as when the class is divided into groups, a new social context was created, in which students get the opportunity to share individual cognition with their peers and arrive at conclusions based on the sum of those cognitions.

A study conducted by Assuah, Yakubu, Asiedu-Addo & Arthur (2016) entitled primary school mathematics teachers' ideas, beliefs, and practices of constructivist instructional strategies. The study contends that there was a little research that has examined teachers' ideas, beliefs and practices of use of constructivist instructional strategies in Ghana. In their quest to cover a lot of topics (material), teachers usually do not employ time-consuming methods that allows for students to construct their main ideas from lesson delivery to one that lends to rote learning. The purpose of the study was to explore Ghanaian primary school mathematics teachers' ideas, beliefs and practices of constructivist instructional strategies. Using a mixed methods approach that is sequential exploratory approach, the outcome from the study revealed

that through Constructivist Instructional Strategies (CIS), pupils were able to construct their own understanding, and were willing to follow learner-centred method of instruction. More so, it created awareness to teachers between social interaction and authentic learning tasks, which happens to be the two main aspects of CIS. Furthermore, it came to light that there is a direct variation between teachers' perceptions of CIS and the use of selected CIS. That is as teachers' perception of CIS increased, their desire to use selected CIS also increases.

2.6.1 Relevance of theory in the study

The theory (Vygotsky social constructivism theory) was the basis on the choice of the teaching style used as intervention. The researcher believed that the use of this theory indicates that knowledge is acquired when students collaborate with other students, teachers and peers. In addition, the level of students potential development (academic achievement) hinges on the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. When learners associate themselves with others, learners learn well thus improving their knowledge on the subject being learnt. A learner is/will be able to achieve his/her learning objectives lest they have conversation with others, interact and apply knowledge they received. Since no man is an island when it comes to the acquisition of knowledge and we depend on each other, students acquire knowledge under adult's facilitation or through peer collaboration. It could be achieved through group discussion, cooperative learning, or any instructional interaction in an educational or training institution, social media forum, religious and market places.

2.7 Identified gaps

Studies in learning styles reveal that designing and delivering learning materials according to personal characteristics helps in enhancing the attainment of learning goals (Fearing & Riley, 2005; Dunn & Griggs, 2000). Depending on individual differences, some people grasp information presented in the form of facts, numbers, steps, theories and mathematical models better than any other form, whilst others prefer visual channels like pictures, diagrams, and simulations to create better understanding. In some cases, some other individuals prefer oral and written information (Dunn & Dunn, 2000; Dunn & Griggs, 2000). The lack of consensus among researchers regarding the usefulness of learning styles makes the categorisation of these learning styles much more complex (see Smith & Ragan, 1999; Kolb & Kolb, 2005; Schellens and Valcke, 2000; Neuhauser, 2002). In another context Dunn & Dunn (2000) identify four ways of learning such as visual, auditory, kinaesthetic and tactile claiming that they are based on the main sensory systems in people.

Thus, they believe one or two of the sensory systems help in determining one's dominant styles of learning even though may vary depending on the task. Students' learning attainments are thus greatly influenced by certain fixed features (Dunn & Griggs 2003). From the above, Dunn and Dunn (1978) notes that people who differ in learning styles possess unique preferences when undertaken different learning activities. In this sense, researchers and practitioners proposed models and instruments to help colleague researchers' measure learning styles. Several researchers like Akdemir and Koszalkab, 2008; Chory, & Mccroskey, 1999; Cuthbert, 2005; Hayes, & Allinson, 1998; Hoover, & Marshall, 1998; Shaw (2012) examined the relationship between instructional strategies and learning styles. These studies

have established that there is a stronger relationship for various learning styles which made students to achieve their learning outcome. Drawing of these researchers these models and instruments have been the backbone of this research.

However, Neuhauser (2002) and Schellens & Valcke (2000) did not find any relationship between learning style and the performance of the students. In addition, there are numerous studies on students' performance in mathematics (Anamuah-Mensah *et al.,* 2004; Roselizawati *et al.,* 2014; Ling *et al.,* 2016; Arthur *et al.,* 2017; Abreh *et al.,* 2018), recent studies have focused on causes of poor performance of students in mathematics (Abreh *et al.,* 2018; Butakor & Dziwornor, 2018; Karikari *et al.,* 2020). Other studies have documented teaching and learning styles and its impact on students' performance (Ajaja & Eravwoke, 2010; Assuah *et al.,* 2017; Ajaja, 2018; Ampadu & Danso, 2018; McMaster & Fuchs, 2020). There exist few studies on cooperative learning (Ajaja & Eravwoke, 2010; Ajaja, 2018; Johnson & Johnson, 2019; McMaster & Fuchs, 2020). However, these studies on cooperative learning above were mostly centred on other subjects such as integrated science and social studies. Furthermore, there was no intervention approach used in the above studies. This brief presentation of the literature demonstrates the critical relationship and gaps between teaching strategies and learning styles

2.8 Summary/Conclusion

The study of Mathematics is and will continue to be the integral part of every pre-tertiary educational system in the world. The level of mathematics a person knows can affect future career choice. Ironically, year in and year out, there is a dip in students' performance in Mathematics. This has generated a lot of debate and discourse. The onus there lie on mathematics educators to employ teaching and learning strategies

that would nurture and sustain students' interest in Mathematics.

As the adage goes that says that no man is an island, so we interdepend on each other to survive as a people. Cooperative enable students to be seekers of knowledge and at the same time develop their social skills. Several research has shown that learning by cooperation improves students learning outcomes. Compared with conventional method, this method has several advantages including bolstering students' self-esteem and confidence."

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter is sub-divided into the following beginning with the design for the study, the location of the study, population, sample and sampling techniques, instrument administration, data collection procedure, data analysis procedure and ethical considerations.

3.1 Research paradigm

This research adopted quantitative research approach. Quantitative research is associated with positivism. Positivists hold a deterministic philosophy in which causes probably determine effects or outcomes. Thus, the problems studied by positivists reflect the need to identify and assess the causes that influence outcomes. such as found tn experiments. It is also reductionistic in that the intent is to reduce the ideas into a small, discrete set of ideas to test, such as the variables that comprise hypotheses and research questions: The knowledge that develops through a positivist lens is based on careful observation and measurement of the objective reality that exists "out there" in the world. Thus, developing numeric measures of observations and studying the behavior of individuals becomes paramount for a post- positivist. Finally, there are laws or theories that govern the world, and these need to be tested or verified and refined so that we can understand the world. Thus. in the scientific method, the accepted approach to research by positivists, an individual begins with a theory, collects data that either supports or refutes the theory, and then makes necessary revisions before additional tests are made ((Creswell. 2009).

3.2 Research Design

The design for the study was quantitative. The process of research involves emerging questions and procedures. data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honors an inductive style, a focus on individual meaning. and the importance of rendering the complexity of a situation (Creswell. 2007). The study made use of both quasi experiment and administration of questionnaire.

Quasi experiment does not involve the randomization of participants to conditions or order of conditions for the study even though the independent variable is manipulated (Cook & Campbell, 1979). The aim of this design is to establish a cause-and-effect relationship. Quasi experimental design can be used to evaluate participant's attitudes or perceptions relative to an event or to assess comfort in applying the information presented in training sessions or with the introduction of new concept (acceptance and efficacy study) (Stratton, 2019). In this wise, one would assume that an increase in knowledge or positive attitude is evident in better score on a post-test of a control group compared to a post-test of an experimental group implies better knowledge or perception relative to an intervention after the post-test (Gall & Borg 2010).

The rationale for choosing quasi experiment and administration of questionnaire was to establish cause-and-effect relationship between cooperative learning and students in Mathematics performance. As stated already, the purpose of the study was to determine the effects of cooperative learning on Siddiq Senior High School's performance in Mathematics. Quasi-experimental involves the manipulation of an

independent variable and it is characterised by already/pre-existing groups of learners rather than assigning learners to treatment at random. It usually involves two groups of learners, namely an experimental group and a control group. It is often difficult to carry out research in school setting because of randomisation issues (Fraenkel, Wallen & Hyun, 2011). In Ghana, Senior High School classes exist as intact groups and in view of that school authorities hardly would cooperate for research purposes because it disrupts the atmosphere of the class.

Moreover, quasi experimental research also controls some of the sources of internal validity. Gall & Borg (2010) opined that a threat to internal validity in this type of design is that the differences that would be shown from the post-test could be the result of pre-existing differences of the groups before the study, and not necessarily the treatment itself. Therefore, there is a need to establish homogeneity between the two groups to minimise any external factors/variable which could directly affect the dependent variable (achievement test). A pre-test test item is used as a leverage (Ary, Jacobs & Sorensen, 2010). Quasi experimental research design was befitting because it allowed some control without disrupting the teaching lessons in the school.

3.3 Population

A research population is generally a large collection of individuals or objects that is the main focus of a scientific enquiry. The population for the study was all form 2studentsfrom Siddiq Senior High School in the Agona West Municipal.

3.4 Sample

Ewanta & Asiedu-Addo (2008) opined that sampling is a means of drawing a proportion from a population. The advantages of sampling from a population include cost effectiveness and time because it is often impossible to collect data from an entire

population. The sample for the study was all form 2 students in General Art 1 and Science 1. These students were purposively selected for the study because they were the only students who do elective mathematics. The table 3.1 below gives a summary of the two classes selected for the study.

3.5 Sampling Technique

Since the number of students in both class were small and in order to reach out to all students in the class, and also to find out the differences between the two selected classes (high and low performing), the purposive sampling method, as proposed by Leedy and Ormrod (2005) was used.

Table 3.1: Sample of Participants

CLASS	BOYS	GIRLS	TOTAL
2ART 1	13	9	24
2SC 1`	13	9	22

Source: Fieldwork, 2022

From Table 3.1, the number of students 2A1 are 24. Of this 13 out of 24 are boys as against 9 girls. The number of enrolments for 2SCI is 22. Of this 9 out of 22 students are girls as against 13 out of 22 boys.

3.6 Data Collection Instrument

The research instrument shows how data was collected for the research and the procedures used in collecting them. The instruments used were tests and questionnaire.

3.6.1 Questionnaire

The questionnaires were purposely designed for research question 1 and 2. Questionnaires are widely used as data collection instruments in various research fields due to their versatility, ease of administration, and ability to collect standardized data from a large number of respondents. They offer a structured means of gathering information from individuals, providing valuable insights into their attitudes, beliefs, behaviors, and opinions. One of the key advantages of questionnaires is their efficiency. Researchers can reach a wide and diverse audience, as they are not constrained by geographical boundaries. This method is particularly useful for large-scale surveys, where data from a significant number of participants are required (Babbie, 2017). Moreover, questionnaires allow for uniformity in data collection.

The questions and response options are standardized, minimizing interviewer bias and ensuring consistency in data collection. This characteristic is vital for quantitative research, where the goal is to obtain quantifiable data (Creswell & Creswell, 2017). However, the effectiveness of questionnaires depends on clear and well-designed questions. Ambiguity, leading questions, or response bias can distort results. Additionally, there may be limitations in exploring complex, context-rich issues, which are better suited for qualitative methods. This questionnaire was constructed and given to the supervisor for inputs and corrections. The vetted questionnaire was then given to different class to get the validity and reliability score. This improved the test construction. A Cronbach alpha of 0.79 was attained from the analysis of the questionnaire that prove that the instrument is highly reliable.

3.6.2 Conducting the quasi-experiment

The instrument for the study was pre-test and post-test mathematics questions as indicated in Appendix A&B. Students were made to sit like how they sit during examination. This was done purposely to provide independent mode of answering the question devoid of cheating. Tests were constructed and given to the supervisor for inputs and corrections. The vetted test was then given to different class to get the validity and reliability score. This improved the test construction. A Cronbach alpha of 0.79 was attained from the analysis of the test that prove that the instrument is highly reliable. The pre-test items were based on number bases. Number bases or numeration system is one of the compulsory mathematics topics. The test items for the pre-test were made up two sections.

The first section (Paper 1) was twenty (20) multiple choice questions which covered all subsections of number bases. Each question number had options from A-D from which students were required to choose from the options the one that is the correct answer. Students were required to answer all questions. The other section (Paper 2) which was the theory part required students to answer four (4) out of five (5) questions. The nature of the questions was to test students' competencies on converting in number bases, construction (drawing) of tables in number bases, equations involving number bases, and solving word problems involving number bases. The duration for the pre-test examination lasted 1hr55minutes or 115 minutes.

The post-test test items followed a similar pattern. This was done after the intervention. However, the post-test item was based on Core Mathematics Topic Modulo Arithmetic. The multiple questions were twenty (20). The other section that is paper two (2) was also made up of five questions in which student were asked to

answer four (4) out of the five questions provided. The first paper tested the general competencies of students as the questions covered every aspect of the modulo arithmetic. On the other hand, the second section tested students' specific understanding of the relationship between number bases and modulo arithmetic. Also, the construction of addition and subtraction of modulo arithmetic tables, equations involving modulo arithmetic and word problems involving modulo arithmetic. The duration for the post-test examination also lasted 1hr55minutes or 115 minutes as the pre-test examination. Each objective question carried a mark making the total marks of twenty. The paper two which required each student to answer 4 out of the five-question carried 20 marks each. In all the objectives and the paper 2 part carried 100 marks.

3.6.3 Intervention

The researcher applied the intervention after the pretest. On Monday day1 (8/08/22) of Week 1, the revision centred on the subtraction, multiplication of number bases with both the control and the experimental classes. Then on Tuesday Day 2 (09/08/22) of Week 1, the researcher revised with the students in both classes on how to convert from other bases to base 10, how to convert from base ten to other bases and then conversion between non-decimal numerals. Then on Wednesday Day 3 (10/08/22) of Week 1, the students in both classes were taken through the revision on the construction of tables involving numeration system (number bases) and how to use the table to answer questions, equations and word problems involving number bases. On Thursday Day 4 (11/08/22) of Week 1 was the collection of the pre-test data. The instrument for the pre-test data collection was examination papers 1 and 2. The students were allowed to learn on their own before the test was conducted. The examination lasted for 1hr 55minutes or 115 minutes for each group. The examination

questions centred on the revision that was carried out with the students in both classes. The two groups of students were put in one examination hall and were invigilated by two teachers. The invigilators were from other department namely English and Social Studies. The examination started at exactly 3:00pm and ended at exactly 4:55 pm.

The cooperative learning specifically the JIGSAW was implemented. This was developed by Elliot Aronson and Associates in the early 1970s. In this approach the teacher introduced the topic and the topics sub sections is divided and shared among the students in groups of five or six called the jigsaw groups. In Jigsaw application, the concept of learning is sub-divided into different segments, and each student is assigned to a sub-topic so as to enable him/her specialize. This makes the students expert in the section assign to them. This leads to the formation of expert group. At the end of the lesson, each group was disbanded and individual within each group solves or answers self-assessment questions independently. The achievement scores of individual members are added up to give the group aggregate scores. The tasks were given to the students to do first individually, then in pairs. Feedbacks were then given, either by result comparisons, allowing time for students to think, result checks, working task using two or more methods, practically performing the activity, all with the intention to create cognitive conflicts.

The interventions lasted for two weeks with the implementation of four lessons each (the last been a tutorial lesson with the same problems) in both the control and experimental groups. The post-test was conducted approximately one week after the interventions. Post-Test are administered after the intervention or treat, allowing researchers to assess changes that occurred as a result of the independent variable.

Unlike the pre-test, which are used to measure the initial conditions or baseline of the participants, post-tests aim to evaluate the effectiveness of the intervention (Cook, & Campbell, 2020). Post-tests enable researchers to quantify the treatment effect by comparing pre-test and post-test scores.

The post-test data collection began the week after the collection of the pre-test data. The post-test data collection began by putting the students in the experimental class, 2A1 into groups of 5 each. In all four (4) groups were formed. Worthy of note is that each group was made up 5 persons each except a group that numbered four (4) due to the number enrolment of students in the class. The researcher then explained to the students the rationale for the groupings and reminded them the need to stick to their group and their group members for the time being. Then students in the experimental group were introduced to modular arithmetic. The researcher began by asking the students to tell him what time is it. After that discussion, the researcher went further and probed from the students the reason why the settings of their wrist watches have the 12-hour or 24-hour bench marks. He then guided them to see that those whose settings are 12-hour day setting means that the day is divided into two equal parts, 12 hours appease. In this case their 13 hour or the hour after the 12-hour mark would be 1.

This is because the clock would wrap around every 12 hours. That is, you will subtract twelve from thirteen as: 13hours-12hours =1hour (1 o'clock), 14hours-12 hours = 2 hours (2 o'clock), etc. That also goes for the 24-hour settings. 25 hours would be 1 due to 25 hours-24 hours= 1hour (1oclok). Thus, the students made inferences that they are going to deal with remainders when a number wraps around a fix object or number. The researcher added his voice by saying that modulo arithmetic

often called the clock arithmetic involves divisibility, congruence (equality) and examines remainders. He guided them to listing the sets of integers that make up each modulo by stating the similarities and differences between number bases and modular arithmetic. Thus, the student could transfer their knowledge from number bases to list the following set of modulo numbers:

Mod 2 = {0,1}, Mod 3 = {0,1,2}, Mod 4 = {0,1,2,3}, …, Mod 10 = {0,1,2,3,4,5,6,7,8,9}.

After this exercise, students were guided to find solution to the following problems in groups:

1)$7mod\ 4 \equiv$? Ans:$3mod\ 43)7mod\ 7 \equiv Ans: 0mod\ 7$

2)$9mod\ 4 \equiv$? Ans: $1mod\ 4$ 4) $7mod\ 10 \equiv$? Ans: $7mod\ 10$

5) $9mod\ 7 \equiv$? Ans: $2mod\ 7$

Each group answered correctly except the counter question number 4. The researcher explained that since the integer 7 wraps around 10, and seven (7) is < (less than 10), it means seven does not or has not reach a point where it can wrap around the number 10. Therefore, the answer remains the same as the question. So, every case as: $\{qmod\ m, where\ q < m\ always\}$ when the integer (q) before the modular number (m) is less than the mod number (m) nothing changes. This activity was carried out during day 5 (Monday-15/08/2022) and 6(Tuesday-16/08/2022). On day 7 that is Wednesday-17/08/22, the students were assigned subdivisions of the topic to the students in the various groups. This has been shown from the table 3.2.

Table 3.2: Intervention Schedule

GROUP NAME	NUMBER OF STUDENTS	ASSIGNMENT/ TASK
1	5	Learn the addition of modulo arithmetic and construction of addition and multiplication tables of modulo.
2	5	Learn the subtraction of modulo arithmetic and construction of addition and multiplication tables of modulo.
3	5	Multiplication of modulo arithmetic and construction of addition and multiplication tables of modulo.
4	5	Learn how to find the modulo of negative numbers and construction of addition and multiplication tables of modulo.
5	4	Addition. Subtraction, multiplication and negative modulo Arithmetic and the construction of addition and multiplication tables of modulo

Source: Fieldwork, 2022

Then on Thursday: Day8 (18/08/22), the researcher gave 5 questions to group one (1) on the addition of modulo arithmetic and one (1) question on addition modulo 5 table. The questions are listed below:

1) $1 + 24\ mod\ 6$ 2) $2 + 19\ mod\ 5$ 3) $7 + 24\ mod\ 7$ 4) $20 + 8\ mod\ 8$

5) Draw an addition $\oplus$ and multiplication $\otimes$table for mod 5 using the set S= {1,2,3}. Use your table to find: 1) $2 \oplus 3$. 2) $2+(2 \otimes 3)$.

The researcher gave group 2, five questions on subtraction of modulo arithmetic to solve. The questions are listed below:

(1) $19 - 24\ mod\ 6$ (2) $(8 - 24)\ mod\ 7$ (3) $19 - 24\ mod\ 2$

(4)$19 - 16\ mod\ 5$ (5) $30 - 24\ mod\ 4$

5) Draw an addition $\oplus$ and multiplication $\otimes$table for mod 5 using the set T= {1,2,3,4}. Use your table to find: 1) $1 \oplus 3$. 2) $2 \oplus (2 \otimes 3)$.

Likewise, Group Three (3) were given 5 questions on the multiplication of modulo.

1) $2 \times 12\ mod\ 7$ 2) $3 \times 10\ mod\ 10$ 3) $3 \times 24\ mod\ 6$ 4) $3 \times 9\ mod\ 5$

5) Construct an addition $\oplus$ and multiplication $\otimes$ table on mod 6 using the set T= {1,2,3,5}.

Use your table to find: a) n, if n $\otimes\ n \otimes 3 = 3$ b) $3 \otimes 2 \otimes 2$.

Moreover, the researcher gave 5 questions to group four (4) on negative modulo arithmetic and one (1) question on addition and multiplication modulo 6 table. The questions are listed below:

1) $-24\ mod\ 6$ 2)$-19\ mod\ 5$ 3) $-24\ mod\ 7$ 4) $-8\ mod\ 8$

5) Construct an addition $\oplus$ and multiplication $\otimes$ table on mod 8 using the set T= {1,2,4,5,6}.

Use your table to find: a) n, if n $\otimes\ (n \otimes 3) = 4$ b) $3 \otimes (1 \otimes 2)$.

Furthermore, group five (5) were given a question each on the addition, subtraction, multiplication and negative modulo arithmetic. Presented below are the questions

1) $3 + 17\ mod\ 6$ 2) $3 - 17\ mod\ 7$ 3) $3 \times 10\ mod\ 7$ 4) $-17\ mod\ 7$

5) Construct an addition $\oplus$ and multiplication $\otimes$ table on mod 9 using the set T = {1,2,4,5,6}.

Use your table to find: a) n, if n $\otimes\ (n \otimes 4) = 6$ b) $3 \oplus (2 \otimes 6)$.

Note:

- Aside group 5, each group were asked to learn the aspects of the modulo arithmetic calculations which they were assign to.

- The researcher asked each group leader to assign alphabets to group members as their new identity (name) within their various group starting with A and ending with E.
- When the groups have finished solving their questions, all members of the groups formed a new group. The new group likewise was named A-E.
- In all, another five groups were formed where each member taught or discussed what he/she has learnt with the members in the new group.

The researcher gave reading assignment on equations and word problems involving modulo arithmetic to the groups for discussion on the following week that is week 3, week ending (22nd-26th Aug, 2022).

On Monday, that is day 8 of (22/08/2022), the researcher brainstormed with the members in each group on equations and some word problems involving modulo arithmetic. After he gave to each group the following questions to solve:

Find the least value(s) *of* x *in the following equations*:

(1) $2 \times x \equiv 4 mod 9$ $(Ans: x = 3$ (2)$5x + 3 \equiv 2 mod 11$ $(Ans: x = 2)$

(3) $16 = 2 mod x$ $(Ans: x = 7 \; or 14)$ (4) $17 = mod x$ $(Ans: x = 4 \; or 7)$

5) a) If today is Wednesday, what day will it be in: (a) 41 days' time (b) 73 days' time.

b) In a certain village a market day is every 5 days. If the market day for this week is on

Tuesday, how many days will it take for another market day to fall on Tuesday?

On Tuesday, Day 9 of (23Aug, 2022) was revision.

Wednesday: Day 9 (24 Aug, 2022)- Post-test examination.

Again, the two groups of students were put in one examination hall and were invigilated by two teachers. The invigilators were from Home Economics and Visual Arts Departments. The examination started at exactly 3:00pm and ended at exactly 4:55 pm as in the case of the post-test.

3.7 Data collection procedure

Before embarking on the data collection, the researcher obtained an introductory letter from the Department of mathematics, University of Education, Winneba to seek permission. The letter spelled out the purpose of the study, the need for individual participation and anonymity as well as the confidentially of respondents' responses. After establishing the necessary contact with the head teachers of the selected school, authorized offices, permission was obtained for the administration of the instruments. The consent of the students was sought for before administration of the questionnaires to the respondents. The purpose of the study was explained to the respondents by the researcher.

The data collection procedure lasted for three (3) weeks. The pre-test lasted for the first week and the subsequent two (2) weeks for the post-test. The researcher employed the JIGSAW for the experimental class or group 2A1**.** Th**e** JIGSAW approach is a type of cooperative learning in which the teacher or the facilitator introduces the lesson, and after that put learners into groups of five or six. Then the subheadings of the topic are divided and shared among the students in each group or the jigsaw group. This leads to specialization thereby leading to the formation of expert group. After everything the groups are dissolved and each student is made to sit at his/her former place then they are assessed independently. Questionnaires were

administered to the same students who took the tests to identify the learning styles by explaining the various items on the questionnaire.

3.8 Data analysis procedure

The data were coded using numeric tally with each representing a particular variable (item). Afterwards, screening was carried out to ward off errors and to ensure accuracy before the analysis was carried out. The gathered was analysed using SPSS version 25. Descriptive and inferential statistical tools were used to analyse the data. Demographic information of respondents was analysed using frequency and percentages. Frequencies and percentages were used for research question 1. For research question 2, means and standard deviations were developed. Similar like research question 1, research question 3 was analysed using frequency, percentages, means and standard deviations. The means and the standard deviations of the pre-test and the post-test scores were compared and contrasted. Then to test for the hypothesis, an independent sample t-test was conducted to established the differences between the experimental and control group. Maverick (2021) opines that a t-test statistic method is used to determine whether there is a significant difference between the means and standard deviations of the two groups based on a sample of data.

3.9 Validity and Reliability

According to Mugenda and Mugenda (1998), validity is the accuracy, meaningfulness and the degree to which results obtained from the analysis of data actually represent the phenomenon of the study. In determining the validity of the instruments before the administration of the questionnaire and the test items is conducted the researcher had presented the items to supervisor and colleagues for analysis and critique. For the purpose of the study, preliminary survey was carried out on a smaller size of

population in private senior high school. The items that were found to be inappropriate for measuring were amicably modified to improve the quality of the instruments, while some were discarded all together and replaced with appropriate ones that increased the validity of the instrument. After collecting the results for the pilot study, the test-retest technique was used to calculate reliability of the instruments. The responses from the instrument were analysed and stored. After two weeks the same instrument was administered to the same sample and the responses analysed. A comparison of the two was made using the correlation coefficient calculated through the SPSS and thus, the higher the coefficient, the higher the reliability of the instrument and vice versa. A Cronbach alpha of 0.79 was attained from the analysis of the questionnaire that prove that the instrument is highly reliable.

3.10 Ethical consideration

The researcher with the aid of an introductory letter from the Mathematics Education department sought permission from the school management team which includes the headmaster, the two assistants and the domestic bursar. Also, the head of department of mathematics was informed before, during and after the data collection procedure."

CHAPTER FOUR

PRESENTATION OF DATA AND ANALYSIS

4.0 Introduction

This chapter presents the data collected using the instruments for data collection and the analysis of the collected data. The data is presented using tables showing mean and standard deviation values for the pre-test and post-test for the control and experimental groups. Also, by presenting an independent sample t-test, this study tested the hypothesis suggested.

4.1 Demography of Respondent

The respondents of this study were mathematics students in second year in Siddiq Senior High School. Two classes chosen purposively for this study were 2 General Art 1 (2A1) and 2 Science 1 (2SCI 1) classes. The number of enrolments for 2SCI 1 is 22 and that of 2A1 is 24. The study sampled 21 students each from the classes to form the sample for the study. Of the 21 students in 2SCI 1, 9 representing 42.9% were girls and 12 representing 57.1% were boys. In 2A1, 13 out of 21 students representing 61.9% were boys and 8 representing 38.1 % were girls.

Table 4.1: Demography of respondents

	2A1		**2SCI1**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Male	13	61.9	12	57.1
Female	8	38.1	9	42.9
Total	**21**	**100**	**21**	**100**

Source: Fieldwork, 2022

4.2 Essential Conditions that influence Cooperative Learning

Research Question One: What are the essential conditions that influence cooperative learning among Siddiq Senior High School students?

The performance of the Ghanaian students in Mathematics have not been encouraging and trend continues. There has been a remarkable drop in the mathematics performance of some Ghanaian students over the last decade in national and international large-scale assessments such as Basic School Certificate Examinations (BECE) and West Africa Secondary School Certificate Examinations (WASSCE). This study from review of literature has put the conditions into three (3), namely the school conditions, teacher conditions, and student conditions. The school conditions include; Inadequate teaching and learning materials, class size, syllabi content overloaded, school climate, and lack of effective supervision, Teacher conditions include; teachers' competence, motivation, teachers' professionalism, and Student conditions include learning style of students, students' attitude, absenteeism, and belief that future success not hinges on education.

4.2.1 School Related Conditions

Using the Likert-type questionnaire, the participants of this study were asked to what extent they agreed or disagreed to the identified school related causes of poor performance of student in mathematics in Siddiq Senior High School.

Table 4.2 presents the response of respondents to School related conditions for improving performance in mathematics such as; teaching and learning materials, class size, syllabi content overloaded, school climate, and effective supervision.

Most of the respondents of this study agreed that teaching and learning materials are essential conditions for improving the performance of student in mathematics in Siddiq Senior High School. Of the 42 respondents, 71% agreed to this statement while

5% disagreed and 24% were not sure. With the statement relating class size as a school related essential conditions for improving the performance in mathematics, 67% of the respondents agreed and 14% disagreed while 19% were not so sure.

Table 4.2: School Related Essential Conditions for Improving the Performance in Mathematics

Statement	Agree / Strongly Agree	Not Sure	Disagree / Strongly Disagree	Total
Teaching and Learning Materials	30 (71%)	10 (24%)	2 (5%)	42 (100%)
Class Size	28 (67%)	8 (19%)	6 (14%)	42 (100%)
Content of Syllabus	25 (59%)	2 (5%)	15 (36%)	42 (100%)
School Environment	25 (59%)	9 (22%)	8 (19%)	42 (100%)
Effective Supervision	20 (48%)	15 (36%)	7 (16%)	42 (100%)

Source: Fieldwork, 2022

The content of the syllabus of mathematics in senior high school was one of the statements posed to respondents and the responses show that 59% agreed that this was an essential condition for improving the performance of students in mathematics in Siddiq senior high school, 36% disagreed and 5% were not sure. With regard to the statement of the school environment being essential condition for improving the performance of students in mathematics, 59% agreed, 22% were not sure and 19% disagreed. Effective supervision as an essential condition for improving the performance of students in mathematics had 48% of the respondents of this study agreeing and 16% disagreeing. Of the 42 respondents, 36% were not sure effective supervision is an essential condition for improving the performance of students in mathematics.

Teaching and learning materials / resources such as books, stationery, furniture, equipment and recreational facilities are invaluable to effective education. Provision of these resources have direct variation on students' performance because they are aiding that boost. When teaching learning materials are available and teachers employ them in their lesson delivery, it enhances the effectiveness of the teachers' lesson delivery. Large class size has also been identified as determinants of academic performance in Mathematics. Studies have indicated that class size, whether large or small can better or derail academic performance. The Mathematics Syllabus is overloaded with content and the time frame is small. In view of the fact that the time frame is short, many teachers are not able to complete the syllabus as well as the reading text assigned to each year. There is always an overlap. The teacher at the next grade level start teaching the topics that pertains to that level although the students did not exhaust and master the lessons for the previous grade level. That leaves a knowledge gap with no one to fill.

School climate comprising of variables such as classroom management, discipline, and leadership styles exhibited by the school heads also influenced students' academic performance (Lee and Shute, 2010). This means it is imperative for heads of schools to use proper leadership skills to garner support of the staff members. It is not a paradox, students performed better in schools where the climate is positive and vice versa (Lubienski, and Crane, 2008). According to Mankoe (2002), is key in the education enterprise as it focuses on six areas of education such as administration, curriculum, instruction, human relations, management and leadership. Effective supervision improves the quality of teaching and learning in the classroom. Effective supervision would curb teacher absenteeism as well as teachers taking French leave in the classrooms. This would not only improve teaching in the schools but will also

help in covering the contents in the syllabus. Thus, students who have bad attitude towards school and learning would be challenged to change their attitudes toward school and learning.

4.2.2 Teacher Related Essential Conditions

Using the Likert-type questionnaire, the participants of this study were asked to what extent they agreed or disagreed to the identified teacher related essential conditions for improving the performance of student in mathematics in Siddiq Senior High School.

Table 4.3 presents the response of respondents to teacher related causes of poor performance in mathematics such as; teachers' competence, motivation, teachers' professionalism.

Table 4.3: Teacher Related Essential Conditions for Improving the Performance in Mathematics

Statement	Agree / Strongly Agree	Not Sure	Disagree / Strongly Disagree	Total
Teacher Competence	25 (59%)	2 (5%)	15 (36%)	42 (100%)
Teacher Motivation	20 (48%)	15 (36%)	7 (16%)	42 (100%)
Teacher Professionalism	30 (71%)	10 (24%)	2 (5%)	42 (100%)

Source: Fieldwork, 2022

This study found out that with regard to the statement of teacher competence, 59% of the respondent agreed that this is an essential condition for improving the student performance in mathematics, while 36% disagreed and 5% were not sure. Also, with the statement of teacher motivation, 48% agreed that it an essential condition for

improving the performance in mathematics, 36% were not sure and 16% disagreed. Of the 42 participants in this study, 71% agreed that the teacher's professionalism is an essential condition for improving the performance of students in mathematics, while 24% were not sure and 5% disagreed.

The competency level of a teacher and as well as the skills can have a positive or a negative effect on students' performance. A teacher who does not have both the academic and the professional teacher qualification would automatically have a negative influence on the teaching and learning of his/her subject or area of specialization. They lack the requisite skills and methods of teaching Mathematics. Students of such teachers do not perform better as compared to those taught with qualified professional teachers.

Lack of motivation that stems from unfavourable conditions also affect teachers' delivery. It is a well-known fact that teachers at the basic level (from primary to senor high) are poorly remunerated in this country. That means that teachers should look for alternative livelihoods to augment their income. The effect is that their will and level of commitment to teach will wane. Agyemang (2005) was of the view that even if a teacher is academically and professionally qualified, but works under unfavourable conditions of service, his/her dedication to work would be less and hence low productive than a teacher who is unqualified but works under favourable conditions of service. In view of this, teacher's enthusiasm, self-determination or self-efficacy has been shown to have an impact on teacher behaviour which in turn impacts on learner's motivation and achievement (Sahakyan, Lamb, and Chambers, 2018). Motivated teachers are more open-minded and are flexible to views on changes in the educational system. Specifically, motivated teachers exhibit positive dispositions and

personality provide more engaging classroom lessons; apply variety of instruction techniques; and build positive relationships with their students. Asamoah (2009), stated that the key to improving performance is motivation, and for this reason employers need to understand what motivates their employees. Mathematics teacher motivation has not been widely instituted in Ghana making teachers not to deliver to their best of abilities (Asamoah, 2009).

In Ghana, most teachers do not see Mathematics as a profession, as a result they do not see the need to do research into new and innovative ways of teaching and learning. So, they use the same method throughout the years thereby producing the same outcome year after year (Butakor & Dziwornu, 2018). Teachers' professionalism can have direct or indirect impact of students' performance. Oduro and Macbeth (2003) asserts that almost 50% of teachers at the senior and Junior Secondary level are not professionally trained as Mathematics teachers. A good teacher must have both knowledge in his/her subject area together with some considerable knowledge in some other fields together with the pedagogy. It therefore beholds on teachers to have both contents and the pedagogy since both work hand in hand.

4.2.3 Student Related Conditions

Using the Likert-type questionnaire, the participants of this study were asked to what extent they agreed or disagreed to the identified student related causes of poor performance of student in mathematics in Siddiq Senior High School.

Table 4.4 presents the response of respondents to student related essential conditions for improving the performance in mathematics such as; learning style of students,

students' attitude, student attendance, and the belief that future success not hinges on education.

Students' learning style they adopt toward the study of mathematics was a statement propounded to the respondents of the study and 67% agreed that this is an essential condition for improving the performance of students in Mathematics while 19% were not sure and 14% disagreed. The attitude of students toward the study of mathematics was also propounded as an essential condition for improving the performance of students in mathematics and 48% of the respondents of this study agreed, 36% were not sure and 16% disagreed. Of the 42 respondents of this study, 59% agreed that student attendance is an essential condition for improving the performance in mathematics, however 5% were not sure and 36% disagreed. With regard to the issue of the student being motivated to study mathematics, the respondents of this study indicated that the enhanced motivation and a motivating environment is an essential condition for improving the performance in mathematics.

Table 4.4: School Related Essential Conditions for Improving the Performance in Mathematics

Statement	Agree / Strongly Agree	Not Sure	Disagree / Strongly Disagree	Total
Learning Style	28 (67%)	8 (19%)	6 (14%)	42 (100%)
Attitude toward mathematics	20 (48%)	15 (36%)	7 (16%)	42 (100%)
Student Attendance	25 (59%)	2 (5%)	15 (36%)	42 (100%)
Motivation	25 (60%)	9 (21%)	8 (19%)	42 (100%)

Source: Fieldwork, 2022

All humans have intelligence and that affects how we perform academically or any field of human endeavour (Nichols and Sutton, 2013). That notwithstanding, every student like every human is unique and have different learning style which stems from differences in ability. In view of this, a good teacher ought to know his/her students well and tailor his/her teaching style to encapsulate all students. Low ability students perform poorly in school and this affects their self-esteem. Nichols and Sutton (2013) suggested that teachers need to establish good rapport with their students. This would enable them to know their students learning needs so as to channel energy and attention to those who need most to enhance performance. Attitude influence performance. Therefore, a students' attitude towards Mathematics will determine the effort he will put in studying mathematics, in learning and developing mathematical skills.

According to Akey (2006) is of the view that students' beliefs about their capabilities and their quest for success in school has direct link with their level of engagement, together with the emotional stress that goes with it. So, attitude do affect what effort a student is willing to put in the mathematical learning process. It is incumbent on mathematics teacher to strive to develop their students' interest in mathematics for good performance. Mathematics phobia and anxiety run through adult and young people as well. This creates another obstacle to Mathematics performance.

Students' attendance is another reason why students perform badly in Mathematics. Some do so for various reasons. Skipping classes has a negative toll on students as it affects their performance (Oduro and Macbeth, 2003). Furthermore, some students believe that their success or failure in life would not depend on schooling as there are

so many crude ways of making it in life (Tella and Tella, 2010). Thus, student's attendance is an essential condition for improving their performance in mathematics

4.3 Students learning style preferences

Research Question Two: What learning styles do students in Saddiq Senior High School employ?

After finding out the essential conditions for improving the performance in mathematics, this research question sought to examine the perceptions of students in Saddiq Senior High School about their learning style preferences. The learning styles involved in the analysis included collaborative, avoidant, participant, dependent, competitive, and independent learning styles. In the avoidant learning style, students tend to be at the lower end of the grade distribution. They are characterized as having high absenteeism, organize their work poorly, and take little responsibility for their learning (Grasha and Riechmann, 1982). Learners who practice the participant learning style are characterized as willing to accept responsibility for self-learning and relate well to their peers. For the competitive learning style, students are described as suspicious of their peers leading to competition for rewards and recognition.

Collaborative learning style is typical of students who feel they can learn by sharing ideas and talents with their peers or classmates. Dependent learning style is characteristic of students who show little intellectual curiosity and who learn only what is required. They view teacher and peers as sources of knowledge and support in respect of the learning process. Independent learning style encapsulates students who like to think for themselves. They prefer to work on their own but will listen to the ideas of others in the classroom. Such students tend to learn the content they feel is important and are confident in their learning abilities (Grasha and Riechmann, 1982).

Descriptive statistics including mean and standard deviation were used to analyse the data, and the findings are presented in Table 4.5. An examination of the findings in Table 4.5 revealed that the standard deviation for each learning style for both male and female was within the acceptable threshold of ±3 for normal distribution of data (Babbie, 2017). The findings also showed that the males had the highest figures in all the learning styles.

Independent learning style was the most preferred learning style for male (M=3.921, SD=0.612) and female (M=3.833, SD=0.548). This was followed by followed by avoidant learning style (M=3.845, SD=0.539) for males and (M=3.784, SD=0.562). The least preferred learning style was collaborative learning style (M=3.532, SD=0.614) for males and (M=3.422, SD=0.529) for females. The findings implied that independent learning style was dominant among the students whilst the collaborative learning style was least dominant among the students. However, it is instructive to state that with the 5-point Likert scale which was used to measure learning styles preferences of the students where the mean score was 3.0 $[(1 + 2 + 3 + 4 + 5) \div 5]$, the findings pointed out that all the learning styles were rated above the mean. Therefore, the researcher concluded that the students highly preferred all the learning styles outlined in the study but in varied intensities.

Table 4.5: Learning style preferences

Learning style	Male	Female
Independent learning style	3.921±0.612	3.833±0.548
Avoidant learning style	3.845±0.539	3.784±0.562
Participant learning style	3.761±0.578	3.752±0.531
Dependent learning style	3.731±0.591	3.746±0.502
Competitive learning style	3.618±0.479	3.611±0.571
Collaborative learning style	3.532±0.614	3.422±0.529

Source: Fieldwork, 2022

The findings establishes that students preferred a mixture of learning styles in studying mathematics, and that all the learning styles outlined in the study were highly practiced among the students. The study further revealed that the independent learning style was dominant among the students whilst the collaborative learning style was least prevalent among the students. This finding confirmed the finding of previous studies, which pointed out that learners practice a variety of learning styles (Kemi et al., 2020; Ogunsanya & Olayinka, 2020).

The inference from this finding as well as the findings of previous studies that learners probably apply different learning styles based on varied content and context. Therefore, the learners are able to opt for learning styles in situations that are mostly likely to yield desirable results. However, it is unclear whether learners are aware of their learning styles, and when it is most appropriate for them to alter their learning styles. This point is crucial because uncoordinated change in learning styles is likely to fail in producing the intended outcomes. Again, the study has provided evidence to support the claim that Grasha and Riechmann's (1982) learning style model receives applicability from diverse cultural contexts.

Meshanu & Esia-Donkor (2023) reported that independent learning style was dominant among the students in studying social studies. Grasha and Riechmann (1982) argue that learning styles can be identified through social and emotional dimensions such as attitudes toward learning, teachers, classmates, content and the classroom environment. The concept of learning styles has elicited an intense interest and discussion among professional educators at all levels of the educational system (Pashler, McDaniel, Rohrer & Bjork, 2008). Smith and Dalton (2005) posit that a learning style is a unique and habitual behaviour of acquiring knowledge and skills through everyday study or experience. Learning style is the way in which each learner begins to concentrate on, process, absorb, and retain new and difficult information (Dunn & Dunn, 1990). This implies a necessity for educators to determine what is most likely to trigger each student's concentration, how to maintain it, and how to respond to his or her natural processing style to produce long-term memory and retention.

4.4 Effects of Cooperative Learning on Mathematics Performance

Finally, tests were conducted to buttress the questionnaire. This study employed a quasi-experimental research design using a pre-test and post-test instrument to measure the effects of cooperative learning on senior high schools' performance in mathematics.

Data was collected on second year students of Siddiq Senior High School. Using mathematical topics – number bases and modular arithmetic – this study conducted a pre-test and post-test survey to determine the effect and the extent to which cooperative learning could improve the performance of students in mathematics.

Data collected during this study was coded and analysed using descriptive statistics (mean and standard deviation). Coding was in this format; scores from 0 – 20 was categorized as poor and coded "0.2", scores from 21 – 40 was categorized as below average and coded "0.4", scores from 41 – 60 was categorized as average and coded "0.6", scores from 61 – 80 was categorized as above average and coded "0.8", and scores from 81 – 100 was categorized as excellent and coded "1.0".

Research Question three: To what extent does cooperative learning improve the Mathematical knowledge of students of Siddiq Senior High School?

To answer this question, the study looked that the performance of the students by comparing the results of the pre-test examination and the results of the post-test examination for both groups.

Descriptive Statistics

4.4.1 Pre-Test

The pre-test procedure started with revision of addition, subtraction, multiplication of number bases with both classes namely 2A1 and 2SCI 1. The researcher revised with the students in both classes on how to convert from other bases to base 10, how to convert from base ten to other bases and then conversion between non-decimal numerals. The students in both classes were taken through the revision on the construction of tables involving numeration system (number bases) and how to use the table to answer questions, equations and word problems involving number bases. The result of the pre-test is presented in table 4.6. Data as seen in the table 4.6 shows that of the 42 students, 15 representing 35.7% performed poorly, 18 representing 42.9% performed below average, and 9 representing 21.4% had an average performance. This result set a basis for the introduction of the intervention which was

cooperative learning to determine the effect on the performance of students in mathematics.

Table 4.6: Pre-test

Pre-Test	Frequency	Percent
Poor	15	35.7
Below average	18	42.9
Average	9	21.4
Total	**42**	**100.0**

Source: Fieldwork, 2022

With 78.6% of the students performing below average, the pre-test set uniform basis to determine whether applying cooperative learning will yield a better performance. The pre-test was carried out generally for all participating students. Of the number of students in the control group (n=21), the minimum score was 0.2 (actual score being 0 -20%) and the maximum score was 0.6 (actual score being 41% - 60%). The mean recorded was 0.343 for the control group with a standard deviation of 0.1568. Of the number of students in the experimental group (n=21), the minimum score was 0.2 (actual score being 0 -20%) and the maximum score was 0.8 (actual score being 61% - 80%). The mean of 0.476 with a standard deviation of 0.1841 was recorded for the group.

Table 4.7: Pre-Test

Pre-Test	N	Minimum	Maximum	Mean	Std. Deviation
Control Group	21	.2	.6	.343	.1568
Experimental Group	21	.2	.8	.476	.1841

Source: Fieldwork, 2022

Building on the study of "number bases" and applying the concept, the researcher carried on the intervention by using the strategy of cooperative learning to help student learn the experimental group modulo arithmetic. The control group studied the topic using the traditional method of learning. Both groups took the post-test simultaneously. Table 4.8 shows the mean and standard deviation scores for the two groups during the post-test.

4.4.2 Post-Test

The students were made to sit in groups and to list the sets of integers that make up each modulo by stating the similarities and differences between number bases and modular arithmetic. The results for the post-test are presented in table 4.8 and table 4.9. From the table 4.8, the control group used independent learning style showed a non-significant change in performance. Of the 21 students in the group, 7 representing 33.3% performed below average and 14 representing 66.7% performed averagely.

Table 4.8: Control Group Post-Test

Control Group	Frequency	Percent
Below average	7	33.3
Average	14	66.7
Total	**21**	**100.0**

Source: Fieldwork, 2022

Table 4.9: Experimental Group Post-Test

Experimental Group	Frequency	Percent
Below average	1	4.7
Average	12	57.1
Above average	4	19.1
Excellent	4	19.1
Total	**21**	**100.0**

Source: Fieldwork, 2022

Looking at table 4.9, the experimental group recorded significant increase in performance when cooperative learning was applied to learning mathematics. Out of the 21 students in the group, 4.7% performed below average, 57.1% performed averagely, and 38.2% performed above average. The indication is that applying cooperative learning to the study of mathematics in Siddiq Senior High School had a positive effect on the performance of students. Kolawole (2008) revealed that Cooperative Learning is more effective than independent learning style in learning of mathematics. The results of that study indicated that students at all levels were found to retain memory much longer, increase the ability to solve mathematics problem, and develop positive attitude towards learning mathematics and have a higher self-esteem.

The second-year students in the experimental group of this study also showed similar traits.

This result set clear the theoretical framework of this study. Nichols (2015) posited that the level of potential development (academic achievement) hinges on the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. This is collaborated by the findings of this study where the results show that the teamwork among the students in the experimental group led to significant increase in performance. Thus, according to Kapur (2018), social construction of knowledge could be achieved through group discussion, cooperative learning, or any instructional interaction in an educational or training institution, social media forum, religious and market places. As students interact with people, the material and immaterial environment, they gain understanding and gather experience which is needed to live successful and functional lives.

Cooperative learning is a teaching strategy that organizes students in small groups so that they can work together to maximize the learning of others. In particular, the cooperative learning approach to education is the place where students are organized in pairs or in small groups to help each other in learning the assigned material. Cooperative learning actively involves students in the learning process and seeks to improve the critical thinking, reasoning and problem-solving skills of the learner (Borich, 2015).

The data on the post-test shows that the control group recorded slight increase in minimum value but same value for the maximum value. Of the 21 students in the control group, the minimum score was 0.4 (actual score being 21% - 41%) and maximum score was 0.6 (actual score being 41% - 60%). There was a slight increase

in mean to 0.533 with a standard deviation of 0.0966. The minimum and maximum scores for the experimental group increased significantly. Out of the 20 students in the group, the minimum score was 0.4 (actual score being 21% - 41%) and maximum score was 1.0 (actual score being 81% - 100%). This resulted in a significant increase in mean to 0.705 with a standard deviation of 0.1746.

Table 4.10: Post-Test

Post-Test	N	Minimum	Maximum	Mean	Std. Deviation
Control group	21	.4	.6	.533	.0966
Experimental group	20	.4	1.0	.705	.1746

Source: Fieldwork, 2022

Table 4.11: Independent Sample t-test

	Levene's Test for Equality of Variance		T-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig (2-tailed)	Mean Diff.	Std Error Diff.	Lower	Upper
Post Test (Control)	131.47	0.04							
Post Test			3.432	21	0.00	0.1902	0.0875	0.0514	0.0975
(Experimental)			5.482	20	0.02	0.2261	0.0954	0.0652	0.1179

Source: Fieldwork, 2022

The Levene's test for equality of variance indicated that the Significance is 0.04. This value means that the second variable – that is the Post-test of the experimental group – is to be considered. The *p*-value – indicated by the Sig 2 value of 0.02 – shows that there is a statistical significance ($p < 0.05$) between the mean performance score of

students using cooperative learning strategy and those using independent learning style. This negates the null hypothesis (H_o) and confirms the alternate hypothesis (H_a). The conclusion therefore is that, there is statistically significance between the mean performance score of students using cooperative learning strategy and those taught using independent learning style. Cooperative learning improves the Mathematical knowledge of students of Siddiq Senior High School. The research that was conducted by Edekor & Agbornu (2020) reached similar conclusion and recommended that Cooperative learning methods would be a viable substitute to independent method of learning of mathematics.

4.5 Summary of Chapter

This study sought to answer three research questions. First the causes of the poor performance of students in mathematics. Second the learning styles employed by Siddiq Senior High School students and third whether cooperative learning has an effect on the performance of students in mathematics in Siddiq Senior High School. The data was presented using percentage frequency tables and comparing means in the form of t-test. The study found out that the essential condition for improving the performance of students in mathematics in Siddiq Senior High School related to the school, the teachers and the students themselves.

The learning styles involved in the analyses included collaborative, avoidant, participant, competitive, and independent learning styles. Independent learning style was the most preferred learning styles for males and females with collaborative learning style being the least for males and females.The study found that cooperative learning had a positive effect on student performance in mathematics. The experimental group that received the intervention show significant improvement in

their scores after they studied mathematics using cooperative learning. Also, the study through an independent sample t-test found out that there existed a statistical significance between the mean performance score of students taught mathematics using cooperative learning strategy and those taught using traditional method.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.0 Introduction

This chapter presents the summary of findings of this study, conclusions made based on the findings and the recommendation as to whether or not cooperative learning can be adopted.

5.1 Summary

The poor way or style of learning among most of the students in Siddiq Senior High School at Agona Nyakrom is affecting their performance in Mathematics. The students are fond of learning on their own even if they have problem of understanding whatever they are learning. This behaviour of learning alone among the students has made most of the students unable to express themselves well when they are communicated to in English Language. Again, it is gradually taking away the spirit of we-feeling from them. This prompted this research in a bid to find solutions to the situation.

Cooperative Learning has been documented in literature to improve students' performances in Mathematics, as it greatly reduces Mathematics difficulty and anxiety, and improves the classroom atmosphere. Cooperative learning arouses students' learning interest, cultivate their exploring ability and creative thinking and improve their team spirit and social communication skills. Again, students perform better using cooperative learning instructional strategy irrespective of their ability level than those students using traditional method. on the bases of this, this study sought to find out; the effects of Cooperative Learning on Student performance in Mathematics in Siddiq Senior High School.

Several related literatures were reviewed in line with the set objectives and this help establish a theoretical framework within which data collected and analysed in this study would settle. The review also added to the knowledge on the cooperative learning strategy and its aspects that would help when applied to the learning of mathematics.

To achieve objectives of this study, this study conducted a survey to determine the effect and statistical significance of cooperative learning on the performance of second-year students. A quasi-experimental research design was used which employed the pre-test post-test method where by means of frequency and percentage tables, mean and standard deviation valuation, and an independent sample t-test, helped ascertain the possibility or viability of the method of learning to enhancing performance in mathematics. The data collected and analysed showed that independent learning style was dominant among the students in studying mathematics and cooperative learning had a positive effect and improves the performance of students in mathematics.

5.2 Summary of Findings

This study sought to answer three questions;

- What are the essential conditions that will improve cooperative learning among Siddiq Senior High School students?
- What learning styles do students in Siddiq Senior High School employ?
- To what extent does cooperative learning improve the Mathematical knowledge of students of Siddiq Senior High School?

The first question was answered by means of frequency tables and percentages. Essential conditions identified in the literature review during this study. With regard to the first question, this study used frequency tables and mean and standard deviation valuation to measure the effect of cooperative learning on students in Siddiq Senior High School. For school related conditions, most of the respondents of this study agreed that teaching and learning materials are essential conditions for improving the performance of student in mathematics in Siddiq Senior High School. Of the 42 respondents, 71% agreed to this statement while 5% disagreed and 24% were not sure.

For teacher related essential conditions, this study found out that with regard to the statement of teacher competence, 59% of the respondent agreed that this is an essential condition for improving the student performance in mathematics, while 36% disagreed and 5% were not sure. Finally, for student related conditions, students' learning style they adopt toward the study of mathematics was a statement propounded to the respondents of the study and 67% agreed that this is an essential condition for improving the performance of students in mathematics while 19% were not sure and 14% disagreed.

The second question was answered by means of descriptive statistics including mean and standard deviation were used to analyse the 5-point Likert scale data. Independent learning style was the most preferred learning style for male (M=3.921, SD=0.612) and female (M=3.833, SD=0.548). This was followed by followed by avoidant learning style (M=3.845, SD=0.539) for males and (M=3.784, SD=0.562). The least preferred learning style was collaborative learning style (M=3.532, SD=0.614) for males and (M=3.422, SD=0.529) for females.

The answer for the research question three was arrived at by running an independent sample t-test to determine whether there was a statistical significance between the mean performance score of students taught mathematics using cooperative learning strategy and those taught using traditional method. The *t*-test revealed that the *p*-value (Sig 2= 0.02 for the experimental group) which is the statistical significance was 0.02 which meet the set standard of $p< 0.05$. The null hypothesis was thus rejected and the alternate hypothesis was accepted. The data therefore shows that cooperative learning improve the Mathematical knowledge of students of Siddiq Senior High School

5.3 Conclusion

Based on the findings, this study made these conclusions;

- Essential conditions such as school related conditions (teaching and learning materials), teacher related essential conditions (teacher competence) and student related conditions (students' learning style) were essential condition for improving the performance of students in mathematics.
- Independent learning style was dominant among the students in studying mathematics with collaborative learning style been the least.
- That cooperative learning has a positive effect on students. Getting student to form groups, peer-teach and learning from each other inspires qualities such as retentive memory, problem solving abilities, cooperation, sharing and coming up with innovative ideas, and developing a high self-esteem. Through cooperative learning, students are able to develop leadership skills, team work abilities, communication skills, and general positive work attitude.
- That teachers of mathematics should adopt cooperative learning as a strategy to improve the performance of students in the subject. This study found out that cooperative learning method significantly improves the performance of students in

mathematics. The learning strategy can help improve student performance and by encouraging its application, teachers and student will both benefit.

5.4 Recommendations

The following recommendations are made in view of the conclusions made in this study.

- The study recommends that mathematics teachers adopt the cooperative learning strategy in order to improve students' performance, social interaction skills and foster meta-cognition in students.
- The study also recommend that workshops should be organized by educational bodies to emphasize and enlighten teachers and mathematics educators on the importance of cooperation. Cooperative learning methods would be a viable substitute to traditional method of teaching and learning of mathematics.
- It is the recommendation of this study that student be made active about the benefits of cooperative learning and the tenets of which will help them improve their performance not only in mathematics but in all aspects of life.

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APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF COOPERATIVE LEARNING ON SENIOR HIGH SCHOOLS' PERFORMANCE IN MATHEMATICS

PRE-TEST QUESTIONS AND MARKING SCHEME

SUBJECT: CORE MATHEMATICS **CLASS:** ……...

NAME: ……..……... **DURATION**: 1hr, 55 min.

This paper is in two sections, **Paper 2** *and* **Paper 1**. *Answer paper 2 and paper 1 in your answer booklet. Paper 2 will last for* **1 hour, 20 minutes** *and paper 1 will last for only* **35 minutes**.

PAPER TWO

Answer **four (4)** *questions only from this section.*

All questions carry **equal** *marks.*

1. **(a)** Multiply 2102_{three} by 122_{three} and leave the answer in base three.

(b) Express 441_{five} as a number in base four.

(c) Find the value of x in $132_x = 42_{ten}$.

2. **(a)** Given that $425_6 = 320_x$, evaluate $123_x - 34_x$

(b) Copy and complete the addition table for base 8 below;

$\oplus$	2	3	5	7
2	4			
3				12
5		10		
7			14	

3. **(a)** The operations * and ∇ are defined in base five as m * n = m +n +2 and

m $\nabla n = 2mn$ where m , $n \in S$

i. Form tables for operations * and △ on the set S

ii. Use your tables to evaluate;

α. $2\nabla(2 * 0)$ β. $(2 \nabla 1) * (1\nabla 1)$

(b) If $(2 \nabla n) * (1\nabla 1) = 11$, find the truth set of n from your tables.

4. **(a)** Solve for the value of x in $2x4_7 = 15x_9$

(b) Solve for the value of x if $\frac{11}{x} = \frac{1000}{x+101}$ is in base two. Leave your answer in base two.

5. **(a)** Draw addition and multiplication tables for base four.

(b) Convert $102_{sixteen}$ to base seven.

(C) Find the valueof x in$52_x + 70_x = 110$.

OBJECTIVE TEST

Answer **all** *questions in this section.*

Each section is followed by four options lettered A to D. Find the **correct** *option for* **each** *question. Shade in* **pencil** *on your answer sheet the answer space which bears the same letter as the option you have chosen. Give only* **one** *answer to* **each** *question.*

Now answer the following questions

1. Convert 1120_{five} to base ten numeral.

   A. 112

   B. 160

   C. 2240

   D 5600

2. If $57_{eight} = 233_x$, find x.

   A. 4

   B. 5

   C. 6

   D. 7

3. Simplify $21_{three} \times 21_{three}$,

   A. 1211_{three}

   B. 1210_{three}

   C. 1201_{three}

   D. 1021_{three}

4. Evaluate $11011_{two} - 101_{two}$

   A. 10010_{two}

   B. 10100_{two}

C. 10110_{two}

D. 10101_{two}

5. Arrange the 11011_{two}, 130_{four}, 26_{ten} in ascending order of magnitude.

A. 26_{ten}, 130_{four} , 11011_{two}

B. 26_{ten}, 11011_{two}, 130_{four}

C. 11011_{two}, 130_{four}, 26_{ten}

D. 130_{four}, 11011_{two}, 26_{ten}

6. Which base five numeral is equivalent to $(4 \times 5^3) + (0 \times 5^2) + (2 \times 5^1) + (2 \times 5^0)$ base ten?

A. 402_{five}

B. 422_{five}

C. 4022_{five}

D. 4220_{five}

7. What is the sum of the following numbers;

256_{eight} , 342_{eight} and 421_{eight}?

A. 1131_{eight}

B. 1141_{eight}

C. 1231_{eight}

D. 1241_{eight}

8. Subtract 436_8 from 1205_8

A. 457_8

B. 547_8

C. 557_8

D. 567_8

9. Arrange the following in descending order of magnitude: 20_{eight}, 30_{six}, 23_{seven}, 19_{twelve}

A. 30_{six}, 23_{seven}, 20_{eight}, 19_{twelve}

B. 19_{twelve}, 30_{six} , 23_{seven}, 20_{eight}

C. 30_{six}, 20_{eight}, 23_{seven}, 19_{twelve}

D. 19_{twelve}, 20_{eight}, 23_{seven}, 30_{six}

10. Find the missing numeral in;

$$\begin{array}{r} 2\ 0\ 1_{three} \\ -\ \times\times\times_{three} \\ \hline 2\ \ 1_{three} \end{array}$$

A. 110_{three}

B. 100_{three}

C. 111_{three}

D. 101_{three}

11. Solve for the answer of $(11011_{two} - 111_{two}) + 10011_{two}$ in base two.

A. 100111_{two}

B. 100011_{two}

C. 100101_{two}

D. 110011_{two}

12. Which of the following numbers is not allowed in octal representation of a number?

A. 4

B. 5

C. 0

D. 8

The table below is the addition table for base five. Use it to answer questions 13 to 14.

$\oplus$	0	1	2	3	4
0	0	1	2	3	4
1	1	2	3	4	10
2	2	3	4	10	11
3	3	4	10	11	12
4	4	10	11	12	13

13. What is the identity element?

A. 1

B. 0

C. 2

D. 4

14. If $n \oplus n = 11$, find the truth set of n.

A. $\{n: n = 1\}$

B. $\{n: n = 3, 2\}$

C. $\{n: n = 3\}$

D. $\{n: n = 4\}$

15. Convert 1342_{five} to the decimal.

A. 130

B. 222

C. 497

D. 321

16. Convert 27_{eight} to base five.

A. 23_{five}

B. 113_{five}

C. 412_{five}

D. 43_{five}

17. What is the place value of 2 in 3240_{eight} ?

A. 8^4

B. 8^2

C. 8^3

D. 8^0

18. What is the value of the digit 3, in base ten, in the numeral 4312_{five}?

A. 53

B. 10

C. 25

D. 75

19. Given $3 \times 5^3 + 4 \times 5^2 + 5p = 3420_{five}$, find the value of p.

A. 7

B. 3

C. 2

D. 4

20. What is the value of x in $52_x + 70_x = 110$?

A. 9

B. 11

C. 10

D. 13

MARKING SCHEME FOR THE PRE-TEST

Section A (20 marks)

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

Section B (80 MARKS)

Q1.

(a) [**4 Marks**]

2102_{three} by 122_{three}

$2\ 1\ 0\ 2_{three}$

$1\ 2\ 2_{three}$

$1\ 1\ 2\ 1\ 1_{three}$

$1\ 1\ 2\ 1\ 1_{three}$ (***M* 3**)

$+2\ 1\ 0\ 2_{three}$

$1\ 1\ 1\ 1\ \ 2\ 2\ 1_{three}$ (***A* 1**)

(b) [**7 Marks**]

$441_{five} = (4 \times 5^2) + (4 \times 5^1) + (1 \times 5^0)$

(***M* 1**)

$= (4 \times 25) + (4 \times 5) + (1 \times 1)$ (***M* 1**)

$= 100 + 20 + 1$

$= 121$ (***A* 1**)

New Base	121	Remainder
4	30	1
4	7	2
4	1	3
4	0	1

(***B* 3**)

$\therefore\ 441_{five} = 1321_{four}$ (***A* 1**)

(c) [9 Marks]

$132_x = 42_{ten}$

$132_x = (1 \times x^2) + (3 \times x^1) + (2 \times x^0)$

(***M* 1**)

$= x^2 + 3x + 2$

Equate the answer to 42

$x^2 + 3x + 2 = 42$ (***M* 1**)

$x^2 + 3x + 2 - 42 = 42 - 42$

$x^2 + 3x - 40 = 0$ (***M* 1**)

$x^2 + 8x - 5x - 40 = 0$ (***M* 1**)

$(x^2 + 8x) - (5x + 40) = 0$

$x(x + 8) - 5(x + 8) = 0$ (***M* 1**)

Q1. C Cont'd

$(x-5)(x+8)=0$ $(\boldsymbol{M\ 1})$

$x-5=0$ $(\boldsymbol{M\ \frac{1}{2}})$

$x=5$ $(\boldsymbol{A\ \frac{1}{2}})$

$x+8=0$ $(\boldsymbol{M\ 1})$

$x=-8$

Since we don't have negative base, $x=5$ $(\boldsymbol{A\ 1})$

[Total = 20 Marks]

Q2

(a) **[15 Marks]**

$425_6=(4\times6^2)+(2\times6^1)+(5\times6^0)$ $(\boldsymbol{M\ 1})$

$=(4\times36)+(2\times6)+(5\times1)$ $(\boldsymbol{M\ 1})$

$=144+12+5$ $(\boldsymbol{M\ 1})$

$=161$ $(\boldsymbol{M\ 1})$

$320_x=(3\times x^2)+(2\times x^1)+(0\times x^0)$ $(\boldsymbol{M\ 1})$

$=(3\times x^2)+(2\times x)+(0\times1)$

$=3x^2+2x+0$ $(\boldsymbol{M\ 1})$

$=3x^2+2x$ $(\boldsymbol{M\ 1})$

Equate the two answers by substitution.

$161=3x^2+2x$ $(\boldsymbol{M\ 1})$

$3x^2+2x-161=0$

$3x^2+23x-21x-161=0$ $(\boldsymbol{M\ 1})$

$(3x^2+23x)-(21x+161)=0$ $(\boldsymbol{M\ 1})$

$x(3x+23)-7(3x+23)=0$

$(x-7)(3x+23)=0$ $(\boldsymbol{M\ 1})$

$x=7$ $(\boldsymbol{A\ 1})$

Then;

$123_x-320_x=123_7-34_7$ $(\boldsymbol{M\ 1})$

$1\ \ 2\ \ 3_7$

$-\ 3\ \ 4_7$ $(\boldsymbol{M\ 1})$

$5\ \ 6_7$ $(\boldsymbol{A\ 1})$

Q2 Cont'd

(b)[5 Marks]

(i) $(\boldsymbol{B}\ \mathbf{5})$ for correct answers in the table.$(-\frac{\mathbf{1}}{\mathbf{2}}\ \boldsymbol{ee})$

$\oplus$	2	3	5	7
2	4	**5**	**7**	**11**
3	**5**	**6**	**10**	12
5	**7**	10	**12**	**14**
7	**11**	**12**	14	**16**

[Total = 20 Marks]

Q3 (a) [15 Marks]

(i)Set $S = \{0, 1, 2, 3, 4\}(\boldsymbol{B}\ \mathbf{1})$

The table for m * n = m +**n** +**2 in base 5**

$(\boldsymbol{B}\ \mathbf{5})$

*	0	1	2	3	4
0	2	3	4	10	11
1	3	4	10	11	12
2	4	10	11	12	13
3	10	11	12	13	14
4	11	12	13	14	20

The table for m $\nabla \boldsymbol{n} = \boldsymbol{2mn}$ **in base 5**

$(\boldsymbol{B}\ \mathbf{5})$

∇	0	1	2	3	4
0	0	0	0	0	0
1	0	2	4	11	13
2	0	4	13	22	31
3	0	11	22	33	44
4	0	13	31	44	112

NB:$-\frac{\mathbf{1}}{\mathbf{2}}$**ee**for the two tables above

(ii)

$\alpha.\ 2\nabla\ (2 * 0)$

$2\nabla\ 4 = 31(\boldsymbol{M1}\ \boldsymbol{A}\ \mathbf{1})$

Q3 Cont'd

$$\therefore 2 \nabla (2 * 0) = 31(\boldsymbol{A}\ \frac{\mathbf{1}}{\mathbf{2}})$$

$\beta .\ (\ 0 \nabla\ 2\ ) * (1 \nabla\ 1)$

$$0 * 2 = 4(\boldsymbol{M}\ \mathbf{1}\ \boldsymbol{A}\ \mathbf{1})$$

$$\therefore (0 \nabla\ 2\ ) * (1 \nabla\ 1) = 4(\boldsymbol{A}\ \frac{\mathbf{1}}{\mathbf{2}})$$

(b)[5 Marks]

$(\ 2 \nabla n\ ) * (1 \nabla\ 0) = 1$

$$4 * 0 = 11(\boldsymbol{M}\ \mathbf{1})$$

So;

$$2 \nabla\ n = 4(\boldsymbol{M}\ \mathbf{1})$$

$$2 \nabla\ 1 = 4(\boldsymbol{M}\ \mathbf{1})$$

$$n = 1(\boldsymbol{A}\ \mathbf{1})$$

$$T.S = \{n : n = 1\}(\boldsymbol{A}\ \mathbf{1})$$

[Total = 20 Marks]

Q4 (a)[10 Marks]

$$2x4_7 = 15x_9$$

$$2x4_7 = (2 \times 7^2) + (x \times 7^1) + (4 \times 7^0) \quad (\boldsymbol{M}\ \mathbf{1})$$

$$= (2 \times 49) + (x \times 7) + (4 \times 1)$$

$$= (2 \times 49) + (x \times 7) + (4 \times 1) \quad (\boldsymbol{M}\ \mathbf{1})$$

$$= 98 + 7x + 4 \quad (\boldsymbol{M}\ \mathbf{1})$$

$$= 7x + 102$$

$$15x_9 = (1 \times 9^2) + (5 \times 9^1) + (x \times 9^0) \quad (\boldsymbol{M}\ \mathbf{1})$$

$$= (1 \times 81) + (5 \times 9) + (x \times 1) \quad (\boldsymbol{M}\ \mathbf{1})$$

$$= 81 + 45 + x$$

$$= 126 + x$$

Equate the two answers to get;

$$7x + 102 = 126 + x \quad (\boldsymbol{M}\ \mathbf{1})$$

$$7x + 102 - 126 = 126 - 126 + x$$

$$7x - 26 = x \quad (\boldsymbol{M}\ \mathbf{1})$$

$$7x - x - 24 = x - x$$

$$6x - 24 = 0$$

$$6x = 24 \quad (\boldsymbol{M}\ \mathbf{1})$$

$$\frac{6x}{6} = \frac{24}{6} \quad (\boldsymbol{M}\ \mathbf{1})$$

$$x = 4 \quad (\boldsymbol{A}\ \mathbf{1})$$

$$\therefore\ x = 4$$

Q4 (b)[10 Marks]

$\frac{11}{x} = \frac{1000}{x+101}$

$11_{two} = (1 \times 2^1) + (1 \times 2^0)$ **(M 1)**

$= (1 \times 2) + (1 \times 1)$

$= 3$ **(A $\frac{1}{2}$)**

$1000_{two} = (1 \times 2^3) + (0 \times 2^2) +$

$(0 \times 2^1) + (0 \times 2^0)$ **(M 1)**

$= 1 \times 8 + 0 + 0 + 0$ **(A $\frac{1}{2}$)**

$= 8$

$101_{two} = (1 \times 2^2) + (0 \times 2^1)$

$+ (1 \times 2^0)$ **(M 1)**

$= (1 \times 4) + (0 \times 2) + (1 \times 1)$ **(A $\frac{1}{2}$)**

$= 5$

By substitution;

$\frac{3}{x} = \frac{8}{x+5}$ **(M 1)**

$3(x + 5) = 8x$

$3x + 15 = 8x$ **(M 1)**

$3x - 8x = 15$

$5x = 15$ **(M 1)**

$\frac{5x}{5} = \frac{15}{5}$

$x = 3_{ten}$ **(A $\frac{1}{2}$)**

Q4 Cont'd

Change 3_{ten} *to base two.*

New Base	3	Remainder
2	1	1
2	0	1

(B 1)

$\therefore x = 11_{two}$

(A 1)

[Total = 20 Marks]

Q 5. (a) **[7 Marks]**

Addition Table for Base Four

⊕	**0**	**1**	**2**	**3**
0	0	1	2	3
1	1	2	3	10
2	2	3	10	11
3	3	10	11	12

$\left(\boldsymbol{B}\ \mathbf{3}\frac{\mathbf{1}}{\mathbf{2}}\right)$

Multiplication Table for Base Four

⊗	**0**	**1**	**2**	**3**
0	0	0	0	0
1	0	1	2	3
2	0	2	10	12
3	0	3	12	21

$\left(\boldsymbol{B}\ \mathbf{3}\frac{\mathbf{1}}{\mathbf{2}}\right)$

(b)[7 Marks]

$C02_{sixteen} = (12 \times 16^2) + (0 \times 16^1) + (2 \times 16^0)$ $(\boldsymbol{M}\ \mathbf{1})$

$= (12 \times 256) + (0 \times 16) + (2 \times 1)$ $(\boldsymbol{M}\ \mathbf{1})$

$= 3072 + 0 + 2$

$= 3074_{ten}$ $(\boldsymbol{A}\ \mathbf{1})$

Q 5 (b) Cont'd

Change 3074_{ten} to base 7

New Base	3074	Remainder
7	439	1
7	62	5
7	8	6
7	1	1
7	0	1

$(\boldsymbol{B}\ \mathbf{3})$

$\therefore\ C02_{sixteen} = 11651_{seven}$ $(\boldsymbol{A}\ \mathbf{1})$

(c) **[6 Marks]**

$52_x + 70_x = 110$

$(5 \times x^1) + (2 \times x^0) + (7 \times x^1) + (0 \times x^0) = 110$ $(\boldsymbol{M}\ \mathbf{1}\frac{\mathbf{1}}{\mathbf{2}})$

$5x + (2 \times 1) + 7x + (0 \times 1) = 110$ $(\boldsymbol{M}\ \mathbf{1})$ $(\boldsymbol{M}\ \mathbf{1})$

$5x + 2 + 7x + 0 = 110$

$12x + 2 = 110$ $(\boldsymbol{M}\ \mathbf{1})$

$12x + 2 - 2 = 110 - 2$

$12x = 108$

$\frac{12x}{12} = \frac{108}{12}$ $(\boldsymbol{M}\frac{\mathbf{1}}{\mathbf{2}})$

Q 5 (C) Cont'd

$$x = 9$$

$$\therefore\ x = 9 \qquad (\boldsymbol{A}\ \mathbf{1})$$

[Total = 20 Marks]

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF COOPERATIVE LEARNING ON SENIOR HIGH SCHOOLS' PERFORMANCE IN MATHEMATICS

POST-TEST QUESTIONS AND MARKING SCHEME

SUBJECT: CORE MATHEMATICS **CLASS:** ……...

NAME: ……..……... **DURATION**: 1hr, 55 min.

This paper is in two sections, **Paper 2** *and* **Paper 1**. *Answer paper 2 and paper 1 in your answer booklet. Paper 2 will last for* **1 hour, 20 minutes** *and paper 1 will last for only 35* **minutes**.

PAPER TWO

Answer **four (4)** *questions only from this section.*

All questions carry **equal** *marks.*

6. **(a)** Copy and complete the multiplication table modulo 5 on the set $\{1, 2, 3, 4\}$

$*$	1	2	3	4
1	1			
2		4		
3	3			2
4		3		

(b) From the table,

(i) solve the expression $2n * 4 = 3$

(ii) find the value of n for which $2 * (3 * n) \equiv 2$

(iii) find the identity element.

(c) Find the value(s) of x if $7 = [(20 - 6 \times 3)] mod\ x$

7. **(a)** Given that $3x + 5 = 2(mod\ 6)$

(b) Draw the addition($\oplus$) and the multiplication($\otimes$) tables for $mod\ 8$ using the set

$S = \{2, 3, 5, 7\}$.

(c) From your table, find the truth set of the equation $(x \oplus 7) \otimes (3 \oplus 2) = 2$

8. **(a)** The operations * and $\triangle$ are defined in modulo five as m * n = m +n +2 and

m $\triangle\ n = 2mn$ where m , $n \in S$

i. Form tables for operations * and $\triangle$ on the set S

ii. Use your tables to evaluate;

α. $2 \triangle (2 * 0)$ β. $(2 \triangle 1) * (1 \triangle 1)$

(b) If $(2 \triangle n) * (1 \triangle 1) = 2$, find the truth set of n from your tables.

9. **(a)** If a woman sends her bouncing baby boy to the hospital on Tuesday, and was asked to visit the hospital every 3 days, find how long it would take her to visit the hospital again on Tuesday.

(b) **(i)** Draw the addition($\oplus$) and the multiplication($\otimes$) tables for $mod\ 6$.

(ii) If $5 \oplus (m \otimes 3) = 2$, find from your table the value(s) of m.

10. **(a)** The girls in a certain house sweep every three days in a week. If a girl sweeps on this Tuesday, what day did she sweep 33 days ago?

(b) Find the least positive value of y in $5y + 3 \equiv 1\ mod\ 11$

(c) (i) Draw an addition ($\oplus$) table for $mod\ 4$.

(ii) From your table, solve$(2 \oplus 2) \oplus (2 \oplus 3)$

OBJECTIVE TEST

Answer **all** *questions in this section.*

Each section is followed by four options lettered A to D. Find the **correct** *option for* **each** *question. Shade in* **pencil** *on your answer sheet the answer space which bears the same letter as the option you have chosen. Give only* **one** *answer to* **each** *question.*

Now answer the following questions

1. What would be the set of possible remainders when 5 divides an integer?

   A. $\{1, 2, 3, 4\}$

   B. $\{0, 1, 2, 5\}$

   C. $\{0, 2, 3, 4, 5\}$

   D $\{0, 1, 2, 3, 4\}$

2. Simplify $19 + 31 (mod\ 6)$.

   A. 4

   B. 2

   C. 6

   D. 7

3. Simplify $13 \times 9 (mod\ 5)$

   A. 4

   B. 2

   C. 6

   D. 7

4. Find the answer to $-2\ mod\ 7$

   A. 3

   B. 7

C. 5

D. 4

5. Find the least positive value of x if $5x \equiv 4(mod\ 6)$

A. 2

B. 5

C. 3

D. 1

6. What number is it if when it divides any positive integer there will be a remainder of 0 to $(n-1)$?

A. 3

B. 6

C. n − 1

D. n

9. In dealing with $mod\ n$, when the answer is negative, we add the multiples of $mod\ n$ till we get an answer between……

A. 0 and 5

B. 0 and n

C. 0 and (n − 1)

D. 0 and n^2

8. A certain market opens for sales every 7th day of the week. If it opened last on a Friday, in what day of the week will the market be opened again after 9 months.

A. Tuesday

B. Wednesday

C. Thursday

D. Friday

9. What will be the time 70 hours after 7O'clock?

A. 7 O'clock

B. 5 O'clock

C. 6 O'clock

D. 8 O'clock

10. Find the least value of x if $4x + 1 = 5 \ mod \ 8$.

A. 1

B. 3

C. 5

D. 7

11. Calculate $[(4 - 9) \times 7] \ mod \ 5$

A. 4

B. 2

C. 0

D. 3

12. Which of the following numbers is not allowed in $mod \ 8$ representation of a number?

A. 4

B. 5

C. 0

D. 8

The table below is the addition table for $mod\ 3$. Use it to answer questions 13 to 15.

$\oplus$	0	1	2
0	0	1	2
1	1	2	0
2	2	0	1

17. What is the identity element?

A. 1

B. 0

C. 2

D. 4

18. If $n \oplus n = 1$, find the truth set of n.

E. $\{n: n = 2\}$

F. $\{n: n = 3, 2\}$

G. $\{n: n = 3\}$

H. $\{n: n = 4\}$

19. If $(1 \oplus 1) \oplus (n \oplus 0) = 1$, find the value of n.

A. 1

B. 0

C. 2

D. 4

20. $3mod7$ is equivalent to the following except…….

A. $-4\ mod\ 7$

B. $10\ mod\ 7$

C. $17\ mod\ 7$

D. $5\ mod\ 7$

17. Calculate $[(13 \times 3) + 9]\ mod\ 8$

A. 3

B. 1

C. 0

D. 7

19. What is the congruence of $22\ mod\ 7$?

A. $8\ mod\ 7$

B. $10\ mod\ 7$

C. $5\ mod\ 7$

D. $7\ mod\ 7$

19. If n represents all integers, which of the following would generate the set of all positive values of x in $(4 + x) \equiv 5(mod\ 7)$.

A. $7n$

B. $2n + 7$

C. $2n$

D. $1 + 7n$

20. Your flight that has to arrive at 3pm is getting delayed by 14 hours due to circumstances beyond control. What time will it land?

A. 9 am

B. 9 pm

C. 5 am

D. 5 pm

MARKING SCHEME FOR THE POST-TEST

Section A (20 marks)

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

MARKING SCHEME FOR POST-TEST (80 marks)

Q1.

(a) [**5 Marks**]

*	1	2	3	4
1	1	**2**	**3**	**4**
2	**2**	4	**1**	**3**
3	3	**1**	**4**	2
4	**4**	3	**2**	**1**

(***B* 5**)

(b) [**8 Marks**]

(i) $2n * 4 = 3$ (***M* 1**)

$2 * 4 = 3$

Then; (***M* 1**)

$2n = 2$

$2 * 1 = 2$ (***M*** $\frac{\mathbf{1}}{\mathbf{2}}$)

$\therefore n = 1$ (***A*₁**)

(ii) $2 * (3 * n) \equiv 2$ (***M* 1**)

$2 * 1 = 2$

Q1. Cont'd

(iii) The identity element is 1 (***A* 1**)

(c) [**7 Marks**]

$7 = [(20 - 6 \times 3)] mod\ x$

$7 = (20 - 18) mod\ x$ (***M* 1**)

$7 = 2 mod\ x$ (***M* 1**)

$7 - 2 = 5$ (***M* 1**)

Find factors of 5.

Factors of 5={1, 5} (***B* 1**)

$7\ mod\ 1 = 0$ (***M* 1**)

$7\ mod\ 5 = 2$ (***M* 1**)

$\therefore\ x = 2$ (***A* 1**)

[Total = 20 Marks]

Then;

$3 * n = 1$ $(\boldsymbol{M\ 1})$

$3 * 2 = 1$ $(\boldsymbol{M\ \frac{1}{2}})$

$\therefore n = 2$ $(\boldsymbol{A\ 1})$

Q2

(a) **[6 Marks]**

$3x + 5 = 2(mod\ 6)$

$3x = 2 - 5(mod\ 6)$ $(\boldsymbol{M\ 1})$ $(-\frac{1}{2}\ \boldsymbol{ee})$

$3x = -3(mod\ 6)$ $(\boldsymbol{M\ 1})$

$3x = -3 + 6(mod\ 6)$ $(\boldsymbol{M\ 1})$

$3x = 3$ $(\boldsymbol{M\ 1})$

$\frac{3x}{3} = \frac{3}{3}$ $(\boldsymbol{M\ 1})$

$x = 1$ $(\boldsymbol{A\ 1})$

(b)[10 Marks]

Addition Table for Modulo 8 $(-\frac{1}{2}\ \boldsymbol{ee})$

$\oplus$	2	3	5	7
2	**4**	**5**	**7**	**1**
3	**5**	**6**	**0**	**2**
5	**7**	**0**	**2**	**4**
7	**1**	**2**	**4**	**6**

$(\boldsymbol{B\ 5})$

Q2. Cont'd

Multiplication Table for Modulo 8

$\otimes$	2	3	5	7
2	**4**	**6**	**2**	**6**
3	**6**	**1**	**7**	**5**
5	**2**	**7**	**1**	**3**
7	**6**	**5**	**3**	**1**

$(\boldsymbol{B\ 5})$

(c) [4 Marks]

$(x \oplus 7) \otimes (3 \oplus 2) = 2$

$(x \oplus 7) \otimes 5 = 2$ $(\boldsymbol{M\ 1})$

$2 \otimes 5 = 2$ $(\boldsymbol{M\ \frac{1}{2}})$

Then;

$x \oplus 7 = 2$ $(\boldsymbol{M\ 1})$

$3 \oplus 7 = 2$ $\left(\boldsymbol{M\ \frac{1}{2}}\right)$

$x = 3$

$The\ Truth\ set = \{x: x = 3\}$ $(\boldsymbol{A\ 1})$

[Total = 20 Marks

Q3 (a) [15 Marks]

a. (i)Set $S = \{0, 1, 2, 3, 4\}(\boldsymbol{B\ 1})$

The table for m ***** n = m **+n +2 in**

$\boldsymbol{mod\ 5(B\ 5)}$

*	0	1	2	3	4
0	2	3	4	0	1
1	3	4	0	1	2
2	4	0	1	2	3
3	0	1	2	3	4
4	1	2	3	4	0

The table for m $\boldsymbol{\nabla n = 2mn}$ **in mod**

5$\boldsymbol{(B\ 5)}$

△	0	1	2	3	4

Q3. Cont'd

(ii)

$\alpha.\ 2 \triangle\ (2 * 0)$

$2 \triangle\ 4 = 1(\boldsymbol{M\ 1A\ 1})$

$\therefore 2 \triangle (2 * 0) = 1(\boldsymbol{A\ \frac{1}{2}})$

$\beta.\ (2 \triangle\ 1) * (1 \triangle\ 1)$

$4 * 2 = 3(\boldsymbol{M\ 1A\ 1})$

$\therefore (2 \triangle\ 1) * (1 \triangle\ 1) = 3(\boldsymbol{A\ \frac{1}{2}})$

(b)[5 Marks]

$(2 \triangle n) * (1 \triangle\ 1) = 2$

$3 * 2 = 2(\boldsymbol{M\ 1})$

So;

0	0	0	0	0	0
1	0	2	4	1	3
2	0	4	3	2	1
3	0	1	2	3	4
4	0	3	1	4	2

NB:$-\frac{1}{2}$**ee**for the two tables above

$2 \triangle n = 3(\boldsymbol{M\ 1})$

$2 \triangle 2 = 3(\boldsymbol{M\ 1})$

$n = 2(\boldsymbol{A\ 1})$

$T.S = \{n: n = 2\}(\boldsymbol{A\ 1})$

[Total = 20 Marks]

Q4 (a)[7 Marks]

S	**M**	**T**	**W**	**Th**	**F**	**Sat**
5	**6**	**0**	**1**	**2**	**3**	**4**

$3mod\ 7 = 3$

$6mod\ 7 = 6(\boldsymbol{M\ 1})$

$9mod\ 7 = 2(\boldsymbol{M\ 1})$

$12mod\ 7 = 5(\boldsymbol{M\ 1})$

$15mod\ 7 = 1(\boldsymbol{M\ 1})$

$18mod\ 7 = 4(\boldsymbol{M\ 1})$

$21mod\ 7 = 0(\boldsymbol{M\ 1})$

Q4. Cont'd

Multiplication table for *mod* 6

$\otimes$	**0**	**1**	**2**	**3**	**4**	**5**
0	0	0	0	0	0	0
1	0	1	2	3	4	5
2	0	2	4	0	2	4
3	0	3	0	3	0	3
4	0	4	2	0	4	2
5	0	5	4	3	2	1

$(\boldsymbol{B\ 4\frac{1}{2}})$

∴It would take 21 days for her to visit the hospital again on Tuesday. $(\boldsymbol{A}\ \mathbf{1})$

(b) **[13 Marks]**

(i) Addition table for *mod* 6

$\oplus$	**0**	**1**	**2**	**3**	**4**	**5**
0	0	1	2	3	4	5
1	1	2	3	4	5	0
2	2	3	4	5	0	1
3	3	4	5	0	1	2
4	4	5	0	1	2	3
5	5	0	1	2	3	4

$(\boldsymbol{B}\ \mathbf{4}\ \frac{\mathbf{1}}{\mathbf{2}})$

Q4. b. ii. Cont'd

$5 \otimes m = 3 \quad (\boldsymbol{M}\ \frac{\mathbf{1}}{\mathbf{2}})$

$m = 5$

$\therefore m = 1, 3\ and\ 5 \quad (\boldsymbol{A}\ \mathbf{1}\frac{\mathbf{1}}{\mathbf{2}})$

[Total = 20 Marks]

(ii)

$5 \oplus (m \otimes 3) = 2$

$5 \oplus 3 = 2 \quad (\boldsymbol{M}\ \frac{\mathbf{1}}{\mathbf{2}})$

$m \otimes 3 = 3 \quad (\boldsymbol{M}\ \frac{\mathbf{1}}{\mathbf{2}})$

$1 \otimes 3 = 3 \quad (\boldsymbol{M}\ \frac{\mathbf{1}}{\mathbf{2}})$

$m = 1$

$m \otimes 3 = 3$

$3 \otimes 3 = 3 \quad (\boldsymbol{M}\ \frac{\mathbf{1}}{\mathbf{2}})$

$m = 3$

$m \otimes 3 = 3$

Q 5

(a) [4 marks]

$(\boldsymbol{B}\ \mathbf{1})$

S	**M**	**T**	**W**	**Th**	**F**	**Sat**
2	**1**	**0**	**6**	**5**	**4**	**3**

$33\ mod\ 7 = 5 (\boldsymbol{M}\ \mathbf{2})$

Five days back from Tuesday is Thursday.

∴she swept on Thursday. $(\boldsymbol{A}\ \mathbf{1})$

	(b) [9 marks] $5y + 3 \equiv 1 \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv (1 - 3) \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv -2 \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv (-2 + 11) \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv 9 \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv (9 + 11) \; mod \; 11 (\boldsymbol{M\ 1})$ $5y \equiv 20 \; mod \; 11 (\boldsymbol{M\ 1})$ $\frac{5y}{5} = \frac{20}{5} (\boldsymbol{M\ 1})$ $y = 4$ $\therefore y = 4 (\boldsymbol{A\ 1})$

Q5. Cont'd **(c) [7 marks]**	

(i) Addition table for mod 4

$\oplus$	**0**	**1**	**2**	**3**
0	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

($\boldsymbol{B}$ **5**)

(ii) $(2 \oplus \mathbf{2}) \oplus (\mathbf{2} \oplus \mathbf{3})$

$0 \oplus \mathbf{1}$ ($\boldsymbol{M}$ **1**)

1 ($\boldsymbol{A}$ **1**)

[Total = 20 Marks]

APPENDIX C

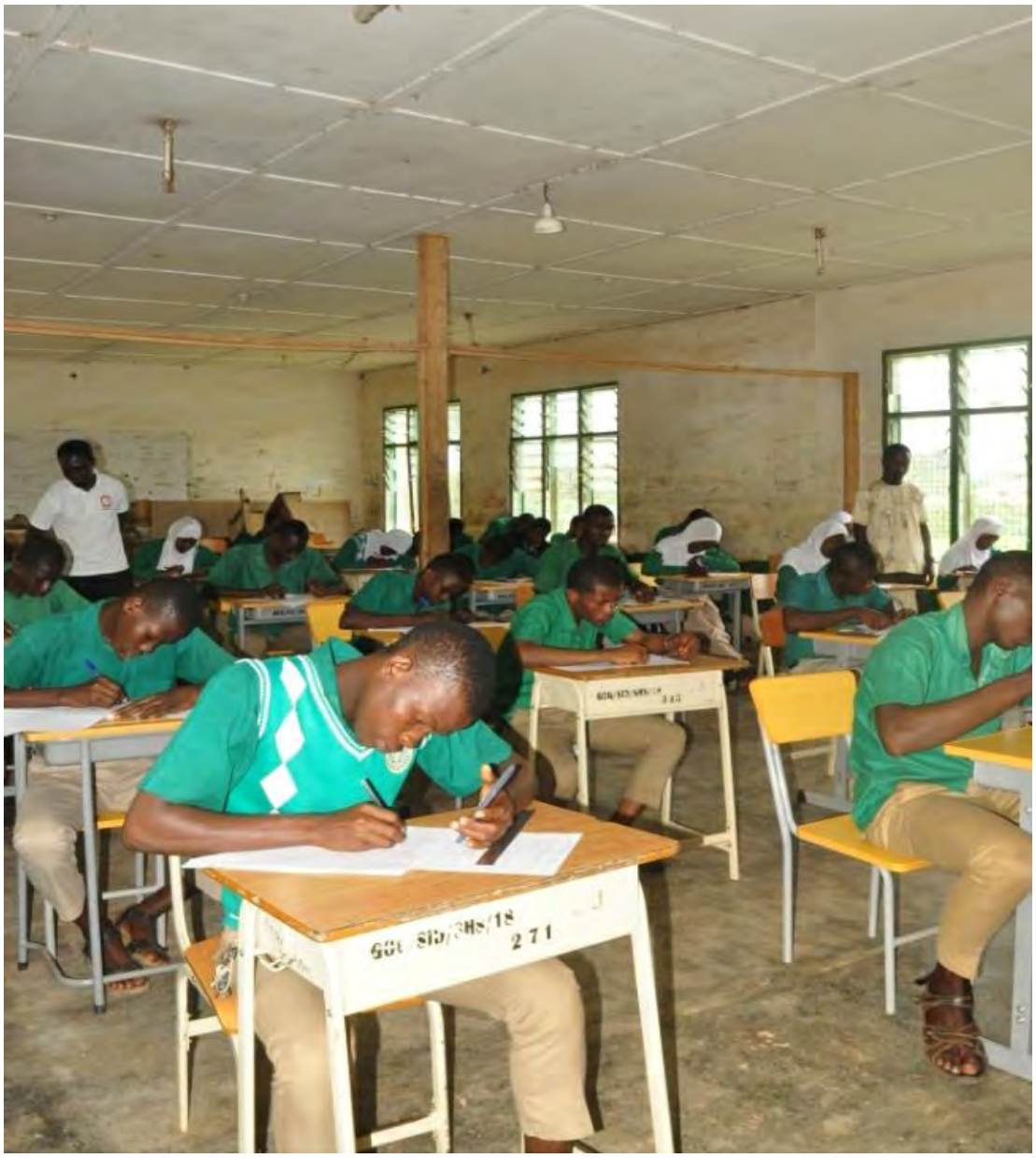

Figure 1: Pre-test

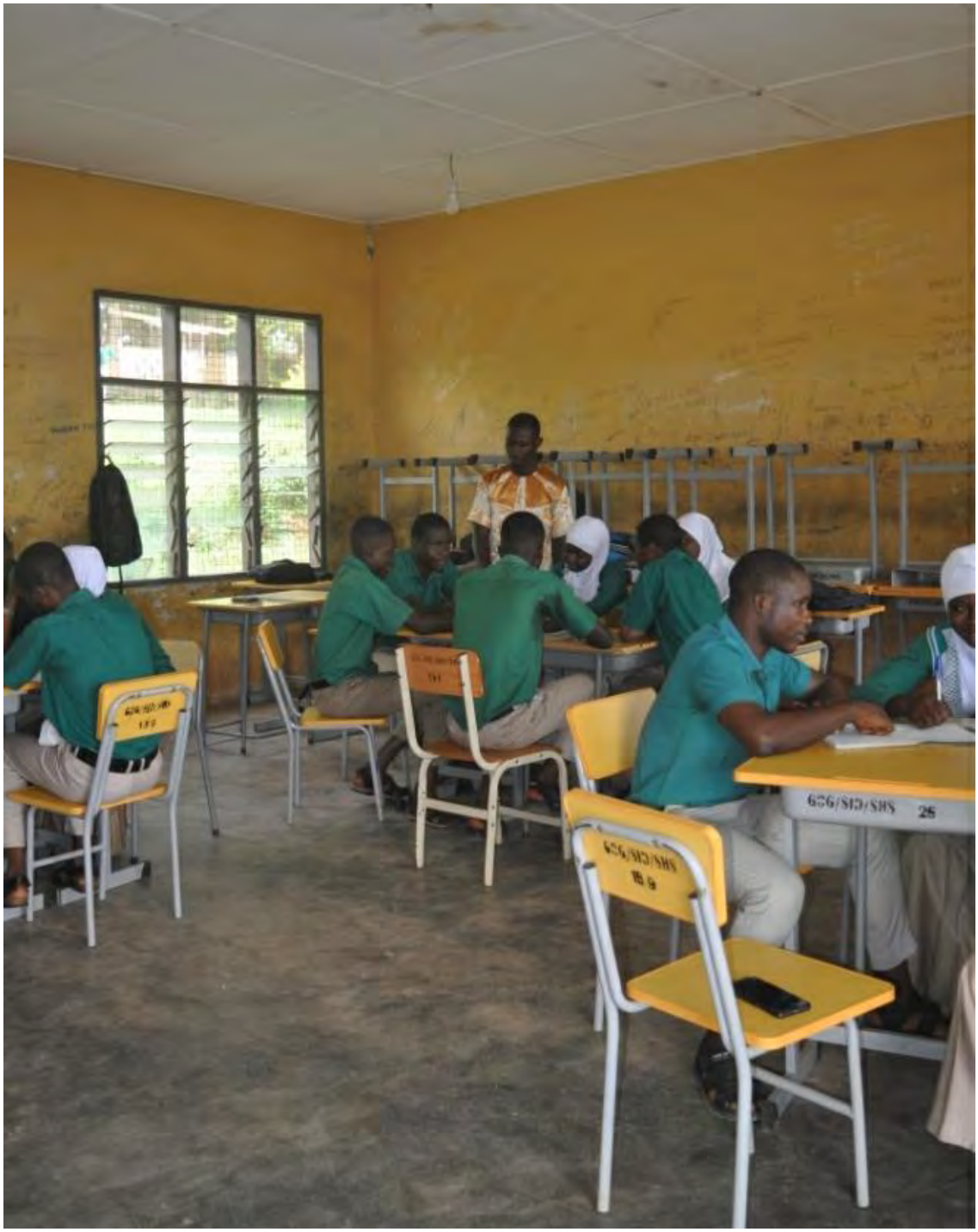

Figure 2: Intervention for Arts Students

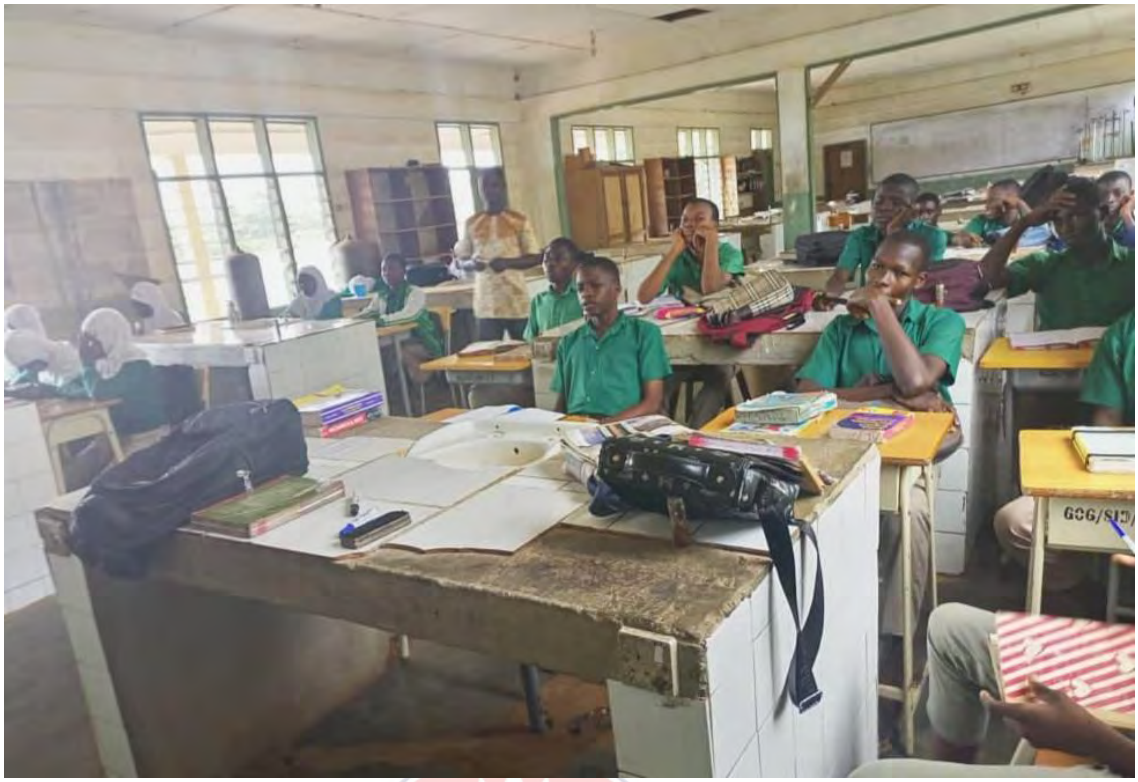

Figure 3: Intervention for Science students

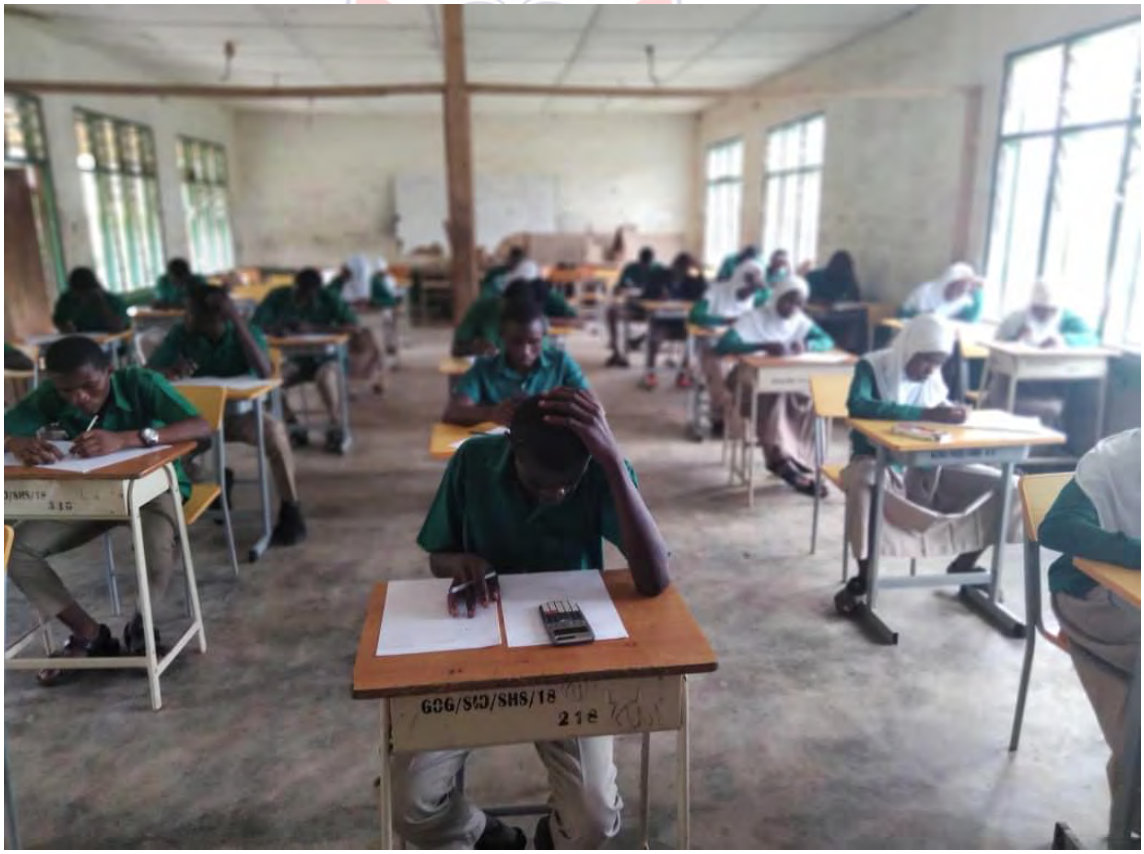

Figure 5 Post-Test for Art Students

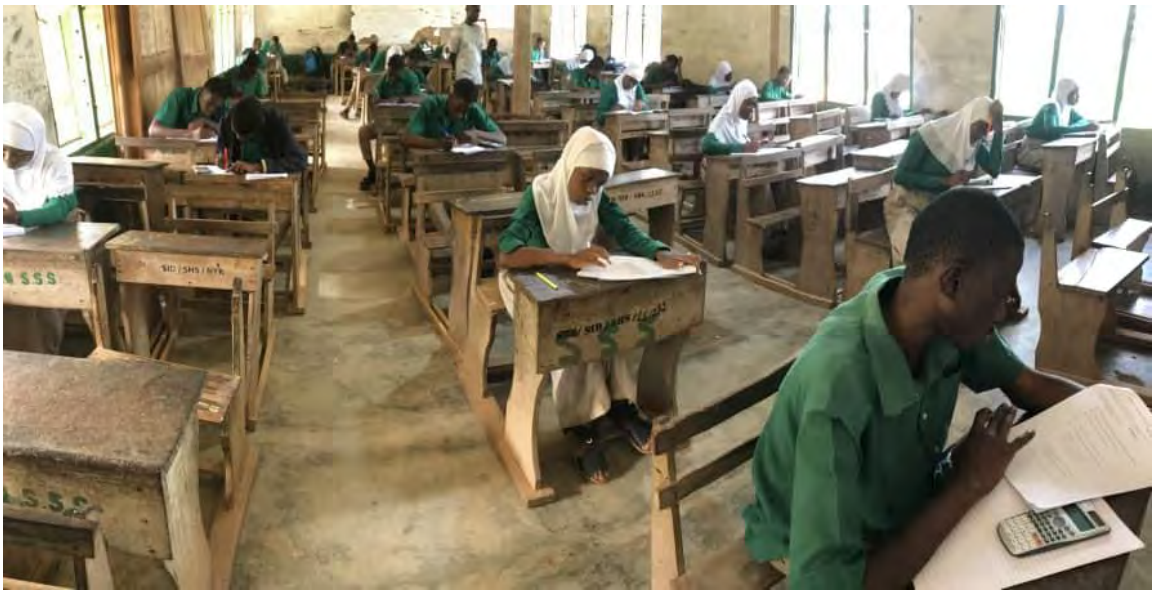

Figure 4 Post-Test for Science Students

APPENDIX D

UNIVERSITY OF EDUCATION, WINNEBA

EFFECTS OF COOPERATIVE LEARNING ON SENIOR HIGH SCHOOLS' PERFORMANCE IN MATHEMATICS

QUESTIONAIRE

Please indicate your response by ticking the corresponding box

Demography

1. Gender

   Male ☐ Female ☐

Essential Conditions to Improve Cooperative Learning

Research Question One: What are the essential conditions that will improve cooperative learning among SHS students?

School Related Conditions

Please indicate your response by ticking the corresponding box

Statement	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Teaching and Learning Materials					
Class Size					
Content of Syllabus					
School Environment					
Effective Supervision					

Teacher Related Essential Conditions

Please indicate your response by ticking the corresponding box

Statement	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Teacher Competence					
Teacher Motivation					
Teacher Professionalism					

Student Related Conditions

Please indicate your response by ticking the corresponding box

Statement	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Learning Style					
Attitude toward mathematics					
Student Attendance					
Motivation					