UNIVERSITY OF EDUCATION, WINNEBA

USING JIGSAW STRATEGY TO ADDRESS SENIOR HIGH SCHOOL STUDENTS' DIFFICULTIES IN SOLVING WORD PROBLEMS INVOLVING LINEAR EQUATIONS

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DECLARATION

STUDENT'S DECLARATION

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

Signature:……..

Date:…….

SUPERVISOR'S DECLARATION

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

Name of Supervisor: Nana Akosua Owusu-Ansah (PhD)

Signature:……

Date:……...

DEDICATION

This work is dedicated to my dear parents, Mr. Isaac and Sarah Saah and my siblings Hannah, Jemima and Nathaniel.

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ABSTRACT

This study compared the effectiveness of the jigsaw learning strategy in the teaching of word problems involving linear equations on the performance of students. The study employed the mixed method approach using quasi-experimental design to address the difficulties students face in solving word problems involving linear equations. The sample consisted of 96 students comprising 46 in the control group and 50 in the experimental group. The two classes were purposively selected for the study. One intact class was used as control group and the other as the experimental group. The instruments used for data collection were achievement tests and semi-structured interview guide. Pre-test and post-test were carried out simultaneously on all the groups using teacher-made achievement test. From the findings, the four major difficulties students encounter when solving world problems involving linear equations were; students attempting but demonstrating misunderstanding of the problem, students attempting and unable to translate problem into linear equation(s), students attempting but fail to solve the equation to reach the solution and students attempting to solve the equation but failing to use the right methods or making errors. The results from the paired sample t-test showed that there is a statistically significant positive effect for the students who used jigsaw strategy to learn word problems involving linear equations [$M = 22.98$, $SD = 6.352$), $t(49) = 9.497$, $p < 0.05$]. Thus, the students taught with jigsaw strategy performed comparably better than their counterpart who did not use it to learn word problems involving linear equations. Also, the jigsaw strategy made lesson more interesting, practical and easy to understand. It was recommended that teachers should incorporate the use of jigsaw strategy in the teaching of word problems involving linear equations.

CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter presents the background to the study, statement of the problem, the purpose of the study, objectives of the study, research questions, significance of the study, delimitations, limitations of the study and organization of the study.

1.1 Background to the Study

Mathematics is the most important subject for the world's economic growth at large since many educational opportunities and jobs require a high level of mathematics knowledge (Kilpatrick, Swafford, & Findell, 2001). According to Anamuah-Mensah (2007), the utilization of science, mathematics and technology has been interlinked with the improvement in productivity and wealth creation of a nation. The subject mathematics is important in many aspects of life and is useful in the workplace, at school, at home, and in the community. Thus, a strong foundation in mathematics is a prerequisite for many careers and professions in today's growing technological society. According to Nabie (2004), the fundamental objective of mathematics education is to enable children to understand, reason and communicate mathematically and solve problems in their everyday life. The ability of students to use their mathematics for purposes beyond doing routine examples and passing formal tests and examinations is a matter of worldwide interest.

Mathematics is made up of many branches including algebra. Algebra is the branch of mathematics that deals with symbolising and generalising numerical relationships and mathematics structures and operating with those structures. The importance of algebra cannot be attributed to only academic purposes but also the world of work since is a

prerequisite for studying every branch of mathematics, science, and technology. It has been a traditional phenomenon that students only begin learning algebra when they enter high school. Word problems are often used to refer to any mathematical exercise where significant background information on the problem is presented as text rather than in mathematical notation (Verschaffel, Greer & De Corte, 2000).

Verschaffel, Greer and De Corte (2000) also stressed that word problems "provide, in convenient form, a possible link between the abstractions of pure mathematics and its applications to the real-world phenomena". As word problems often involve a narrative of some sort, they are occasionally also referred to as story problems and may vary in the amount of language used. Mathematics word problems among mathematics problems mostly deal with the relating real-world phenomenon to mathematical concepts. For many students, the transformation of word problems into arithmetic or algebra causes great difficulty, and a number of studies have addressed the linguistic and mathematical sources of that difficulty from a psychological point of view.

Mathematical achievement of Ghanaian students in recent times has been a subject of great concern among educators, policymakers and the public at large. Students' performance in mathematics at the Senior High School has not been encouraging of late. Candidates are reported to exhibit a poor understanding of mathematical concepts and are unable to form appropriate mathematical models which could be tackled with the requisite (West African Examination Council, 2012). It has also been realized that many students have developed a negative attitude towards the study and learning of mathematics as a result of the way and manner certain concepts are presented to them.

It has been revealed that the traditional method of teaching algebra in Senior High Schools makes it abstract and difficult (Andam, Okpoti, Obeng–Denteh & Atteh, 2015). Andam, Okpoti, Obeng–Denteh and Atteh (2015) noted that learners experience serious problems in understanding algebraic concepts. The type of teaching method employed by teachers has great influence on students' academic achievement. According to Andam, Okpoti, Obeng–Denteh, and Atteh (2015), teaching should allow students to wonder why things are, to inquire, to search for solution and to resolve incongruities.

Several other factors contribute to learners' learning challenge of conceptual knowledge in algebra. Of all these factors, the lecture method was the one that predominantly affect senior high school learners' learning of algebra in classroom instruction. Educators need to be motivated by this problem of learning to be careful while selecting an appropriate learning strategy that best suits for the learning of any given algebra lesson and for that matter special attention has to be paid to the appropriate learning strategy that entertain learners' various learning styles, their prior knowledge, and experiences. The traditional or conventional lecture method that instructors often employ has contributed to learners' being unable to attain meaningfully in the learning of algebra. Dhage, Pawar and Patil (2016) described that the traditional teaching method is usually a teacher-centred method. This means a teacher prepares short notes and presents the lesson only through talking and writes short notes on the black/whiteboard, and students passively listen and take their short notes.

Cooperative learning is an international pedagogical practice that makes learners active in the process of learning from pre-school to tertiary level in different subject

areas (Davidson, 2021). Cooperative learning is a teaching method where students of mixed levels of ability are arranged into groups and rewarded according to the group's success, rather than the success of an individual member. Considering all these definitions, the cooperative learning can be defined as a learning approach where students join small mixed groups to achieve a common goal by assisting each other's learning, actively participate in learning activities, and increase their communication, self-confidence, critical thinking, and problem-solving skills (Doymuş, Şimşek & Bayrakçeken, 2004). Cooperative thinking is widely considered a single method and to have a single application technique. However, there are many different cooperative learning techniques (Namlu, 1999; Açıkgöz, 2007). One of these techniques is the jigsaw learning strategy.

Jigsaw strategy was developed by a social psychologist Elliot Aronson in 1971 to reduce prejudice and promote better intergroup relations among students in a desegregated school in Austin, Texas. The name jigsaw reflects the idea of students coming together like pieces of a puzzle to collaborate and learn from one another. According to Aronson (2000) jigsaw groups are developed in the class whereby each student in the group is assigned his/her part to work on. Then the groups are reconstituted with students having identical assignment put together. Then the students go back to their initial jigsaw groups to present their well-organized report to the group. Just like jigsaw puzzle, each piece (student part) is essential for the completion and full understanding of the final product.

Jigsaw strategy steps according to Aronson (2000) are:

1. The teacher divides the students into 4 or 5 people's jigsaw groups which should be diverse of gender, ethnicity, race and ability.

2. The teacher divides the lesson into 4 or 5 segments.
3. The teacher gives each student in each group a segment of what is to be learned.
4. The students are given time to write down their segment and become familiar with it.
5. Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their specific task and also refer from the text books.
6. The teacher brings the students back to their jigsaw groups.
7. The teacher asks each student to present his or her task to the group.
8. The teacher floats from group to group observing the process. If any group is having any trouble, the teacher makes an intervention.

Davidson, (2005) points out the following benefits of jigsaw strategy as they apply to mathematics teaching;

1. Mathematical problems can be solved by several different approaches.
2. Students in groups can help one another master basic facts and necessary procedures.
3. Students can persuade one another by the logic of their arguments to find solutions to mathematical problems.

Jigsaw learning strategy and its impact on teaching and learning scenarios have been the subject of numerous studies. Some of their conclusions include the fact that the jigsaw learning technique fosters an atmosphere of engaged, active learning. When students actively participate in formulating questions in their own language and coming up with answers together rather than copying information from the teacher or

the textbook, this method fits in well with the constructivist approach and this necessitated the reason for choosing jigsaw strategy for the study.

1.2 Statement of the Problem

As a practicing mathematics teacher, who has taught at the basic school for two years and seven years at the senior high school level, the researcher observed that many students consistently perform poorly in solving word problems. A particular example was manifested in their class exercises, mid-semester examination and end of semester examinations. A content analysis was conducted by the researcher on students' marked scripts from the mid-semester examination and end of semester examination and identified that most students have problems in answering word problem questions. Out of the 30 students who participated, only 6 representing 20% could answer all the questions correctly. In particular, 40% could answer two to three questions halfway, while 40% could not answer any question correctly.

The results really showed that students have difficulties in solving word problems. This is supported by Sepeng (2013) who observes that solving algebraic word problems is a challenge to learners because of the unrealistic strategies that they tend to use in solving these problems. Sepeng (2013) goes further to acknowledge that in order to successfully solve algebraic word problems, learners need to know how to use text to identify missing information, construct number sentences and set up a calculation strategy for finding the missing information. In the recent West African Senior School Certificate Examination (WASSCE 2018, 2019, 2020), among the several topics that were captured as weaknesses of student in the yearly Chief Examiners Report students' difficulty in algebra related topics remained consistent in the reports for the past three years reportage.

The chief examiner's report from the West African Examination Council (2018) for Mathematics (Core) for instance, listed some of the weaknesses of candidates as difficulty in: translating word problems into mathematical statements; solving problems on probability; solving equation simultaneously involving indices; and solving problems involving mensuration. The chief examiner's report from the West African Examination Council (2019) for Mathematics (Core) report also touched on; translating word problems into mathematical statements; solving probability related problems; solving basic computation without the use of calculator; solving problems involving mensuration and showing evidence of reading from a graph. The chief examiner's report from the West African Examination Council (2020) for Mathematics (Core) report as well also commented on the following weaknesses among students; translating word problems into mathematical statements; solving problems on probability; solving equation simultaneously involving indices; and solving problems involving mensuration.

A study on the effectiveness of jigsaw cooperative learning strategy on academic performance on secondary students in mathematics revealed a significant difference in performance in favour of students exposed to the jigsaw cooperative learning strategy Chianson, Kurumeh, and Obida, (2011) and Kolawole (2008) in their separate studies. However, a major gap in these studies is that they provided generalized conclusion of cooperative learning in mathematics without narrowing it down to specific topics. This study sought to investigate the effects of jigsaw strategy on high school students of St. Mary's Boys' Senior High School, Apowa to improve their word problems skills.

1.3 Purpose of the Study

The purpose of this study was to use jigsaw strategy to address students' difficulties in solving word problems involving linear equations.

1.4 Objectives of the Study

The study was guided by the following specific objectives;

1. To identify the difficulties that students encounter in translating word problems into linear equations and vice versa.
2. To find out students' views about jigsaw strategy in learning word problems
3. To determine if there is a difference between the performance of students taught by jigsaw strategy and those taught using the traditional approach?

1.5 Research Questions

The following research questions were formulated to guide the study:

1. What difficulties do students encounter in translating word problems into linear equations and vice versa?
2. What are students' views on jigsaw strategy in teaching word problem?

Hypothesis was set for the third objective, that is;

H_0: There is no significant difference between the performance of students taught by jigsaw strategy and those taught using the traditional approach.

1.6 Significance of the Study

This research work is significant as the findings of this study would help improve classroom teaching and learning of mathematical concepts. It would hopefully reduce the problem of poor performance in mathematics as jigsaw strategy would boost learners' achievement level and create a relaxed, interactive and interesting classroom

environment for effective learning. The findings of this research would enjoin mathematics teachers to adopt jigsaw strategy in teaching as it can help break challenging mathematics concepts into smaller sub-units, as such making the teaching process easier and more interesting for the teacher. It would also guide teachers on how to use jigsaw strategy as a means of enhancing participation of students in meaningful activities that involve social interaction amongst students.

The findings of this study would also help students in developing the right attitude towards learning mathematics, as jigsaw strategy would make complex mathematics concepts seem simple and as such interesting. The result of this research would also help authors of mathematics textbooks by equipping textbook writers with appropriate teaching methods like the jigsaw strategy. This would help them in the structure and write-up of their future publications. The findings of this research would also be useful to educational planners, school administrators and principals of schools. It will expose them to the realities of modern educational practices, and make them encourage their staff to adopt jigsaw strategy in their everyday teaching.

1.7 Delimitation of the Study

The study was delimited to the students of St. Mary's Boys' Senior High School in the Ahanta West Municipality of Western Region and two intact classes in the first year Business and General Science class was used for the study. The main rationale for using the first-year students in the study is that the topic is within the scope of the first-year mathematics curriculum. Again, the study was confined to word problems involving linear equations.

1.8 Limitations of the Study

In educational research, large data cases increases the reliability of the information that is gathered. Therefore, it would have been proper to cover the entire form one students of St. Mary's Boys' Senior High School but due to the organization of lessons as the researcher is a tutor of the school and in view of other constraints such as time, the study was restricted to cover only two intact classes in the first year class of St. Mary's Boys' Senior High School.

1.9 Organization of the Study

Chapter one deals with the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, limitation and delimitation of the study.

Chapter two deals with the review of related literature on the theoretical framework of the study, mathematical word problem and problem solving, students' difficulties in solving word problems, and empirical literature

Chapter three also deals with the research design, population, sample and sampling technique, research instruments, treatment of groups, validity and reliability of the instruments, data collection procedures, data analysis and ethical considerations.

Chapter four presents the results and discussion of the findings of the study.

Chapter five is the final chapter of the study. It gives the summary of the study and draws conclusions on the key findings of the study. It outlines recommendations from the study and suggested areas for further research.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter presents a detailed theoretical framework followed by concept of instructional strategy, techniques and methods, critical analysis of similar studies and finally implication of literature reviewed on the study.

2.1 Theoretical Framework

This study was guided by cognitive developmental and social interdependence theories as widely applied in education practices and which is represented by different opinions, view and arguments of researchers in the of field of education. Jigsaw has its root in philosophy and psychology such that its general principles and applications have largely been incorporated in the exercise of teaching and in developmental theories mainly based on the theories of cognitive developmental theory by Jean Piaget and social interdependence theory. The developmental perspective, based on these theories, holds that task-focused interaction among students enhances learning by creating cognitive conflicts and by exposing students to higher-quality thinking.

Cognitive Developmental Theories: Jean Piaget was a Swiss psychologist who was particularly concerned with the way thinking develops in children from birth till young adulthood (adolescents) popularly referred to as Piaget's theory of cognitive development. Piaget's work identified that, between early stages and teenage years, children pass through different developmental phases which are correlated with brain development and growth (as cited in Ojose, 2008).

A further viewpoint on small group learning is based on Piaget's (1932) theory of socio-cognitive conflict, which occurs when children are compelled to re-examine

their understandings and perspectives in the light of contradictions that occur from interacting with others. When this happens, children reflect on their own understandings, seek additional information to clarify contradictions and attempt to reconcile their perspectives and understandings to resolve any inconsistencies. "Cognitive conflict is a catalyst for change as it motivates children to reassess their understandings of the world and to construct new ones that fit better with the feedback they are receiving" (Gillies & Ashman, 2003, p. 12). As students interact with their peers in a jigsaw learning environment, they come to a point where they examine their ideas with that of their peers and where there are inconsistencies, they then seek for further clarifications. Interacting with peers is a primary impetus for change because children are very forthright when stating their ideas (Gillies & Ashman, 2003). They speak directly to each other in ways that can be understood easily, and children are strongly motivated to reconcile differences between themselves and others (Damon, 1984). Moreover, students are often more amenable to their peers' ideas than to those of their teachers because peers' ideas are seen as more personal and less threatening. From Piaget's theory, it is evident that when it comes to learning, students need to interact with their peers in order to sharpen their understanding.

Social Interdependence Theories: Lev Vygotsky portrayed children as social beings intertwined with other people who were eager to help them learn and gain skills. Social interdependence theory has also played a critical role in explaining cooperative learning which presupposes that the way social interdependence is structured determines the way persons interact with each other. The theory began in the early 1900s with the Gestalt school of psychology and was further developed by Kurt Lewin in 1935 who stated that the essence of group work was the interdependence amongst its members, created by common goals. Moreover, outcomes are the

consequence of persons' interactions. Therefore, one of the cooperative elements that have to be structured in the classroom is positive interdependence or cooperation (Johnson, Johnson, & Holubec, 1998). When this is done, cooperation results in promotive interaction as group members encourage each other's efforts to learn (Johnson, Johnson & Holubec, 1998). David and Roger Johnson's were also influenced and also built on the earlier works by developing the social interdependence theory in the 1970s, which states that positive interdependence results in positive interaction as individuals "encourage and facilitate each other's efforts to learn" (Johnson & Johnson, 1999, p.187).

Johnson and Johnson developed social interdependence theory into two types: positive (cooperation) and negative (competition). Positive cooperation exists when individuals understand that they can only achieve their goals if others reach theirs, i.e., they are inextricably linked. It is re-emphasized that all the above perspectives share the common assumption that knowledge must be constructed to be meaningful and this can be achieved through active involvement of the student where the student interacts with other students or even the instructor. It is through the Vygotsky's theory that terms such as cooperative learning, discovery learning, scaffolding and collaborative learning originated. Therefore, this study was guided by the social independence theories in order to use jigsaw strategy to address students' difficulties in solving word problems involving linear equations.

2.2 Concept of Instructional Strategies, Techniques and Methods

Instructional strategies are the techniques that a teacher can adopt to meet the various learning objectives (Richa, 2014). These strategies help student to walk on the path of independent learning and become strategic learners. They equip teachers to make

learning fun and help students to awaken their desire to learn. Instructional strategies focus on not only the educational content but also on the method and environment of the teaching process. Students' development level, interests and experience are considered while choosing a particular teaching strategy so that they can self-accomplish their goals.

In the same vein, Marzano, Pickering and Pollock (2001) focused their attention on successful instruction and found twenty-one instructional strategies that can be useful and beneficial in enhancing student achievement. Their purpose for conducting the study was to recognize instructional strategies that have a high probability of producing the desired learning outcome for all students. However, it is important for teachers to not only know the subject matter, but they must also become knowledgeable of appropriate strategies that will help produce learning outcomes for each student (Erickson, 2008).

Ayeni (2011) expressed teaching to be a means of initiating a meaningful change in learners which may result to changes in learners' behaviour to accomplish an unambiguous result. Adunola (2011) pointed out that academic tutors have a duty to use a proper teaching methodology to achieve learning in the classroom. Also, an instructional strategy is productive when it suits learner's aspiration, as such, it is advised that a suitable teaching method that will accommodate students' weakness should be employed to attain academic excellence (Zeeb, 2004).

Instructional strategy is a method the teacher would use in teaching (in the offline classroom, online, or in some other medium), to help activate students' curiosity about a class topic, to engage students in learning, to probe critical their critical thinking skills, to keep them on task, to engender sustained and useful classroom

interaction, and in general, to enable and enhance the learning course content (University of Regina, 2016).

Obara and Okoh (2005) regard instructional strategies and materials as "all the things the teacher utilizes to interactively enhance, motivate and facilitate teaching and learning in an attempt to ensuring the achievement of a set objectives." The effectiveness of instructional materials and strategies depends upon the manner and degree to which they meet the needs of the teacher and students. Instructional strategies and materials are selected based on the principles of provision of accurate materials that will enrich and support the curriculum, taking into consideration the interest, abilities and maturity levels of the students. Teachers should be encouraged in every way to use instructional strategies as it makes learning more concrete and meaningful (Buseri and Dorgu 2011).

Instructional strategies determine the approach a teacher may take to achieve learning objectives. Some of these instructional methods include demonstration, discussion, inquiry and lecture among others. There can be no successful teachings without application of a method or the other. This is because teaching is a complex activity that involves the subject matter, methods and materials as well as human being who have physical, emotional, psychological and intellectual reactions. Thus, for the effective teaching and learning process in mathematics to take place it is expected that teachers should be equipped with the knowledge of teaching methods. A method is an approach to instruction, that is, the way by which a teacher decides how learning will take place effectively. It can as well be conceived as the ways by which the teacher delivers what he intends to teach the learners. There are numerous teaching methods and each method makes special contribution(s) to teaching and learning. In this

regard, the teacher has a wide variety of methods to call upon in helping his students to learn. But the teacher should understand the peculiar characteristics, intents, merits and demerits of each method in order to be able to choose the one, in each situation, which will most effectively serve the needs for the students.

Grasha (1994) explained that it is important for academic institution to use a reliable measure to access teacher's activities in the classroom. The researcher mentioned that any method that will be used to stimulate teacher's performance must be made simple. Although, he developed specific teaching styles, Grasha (1994) warned against boxing teachers into a single category. Instead, he advocated that teachers play multiple roles in the classroom. Grasha (1994) believed most teachers possess some combination of all or most of the classic teaching styles.

Diverse means can be used in teaching a unit of work so as to give the students the opportunity of making all their learning permanent. It has been advised that for the purpose of practicing theory and enhancing skill development in students, teachers should discard the habit of exclusive reliance on instructional technique and adopt rather the practice of using combination of two or more techniques that match the students and contents they are teaching.

2.3 Jigsaw Strategy and Students' Academic Performance

Instructional strategies comprise the principles and methods used for instruction to be implemented by teachers to achieve the desired learning in students. These strategies are determined partly on the subject matter to be taught and partly by the nature of the learner. A functional teaching and learning approach like cooperative learning can be deployed to different academic levels and also it has the capacity to address individual differences among students.

Jigsaw, is a form of cooperative instructional strategy, and it has been used with great exploit. Jigsaw is a learning exercise which splits learners into clusters in which every cluster member concentrate on a particular concept. After they finish their exercise, a fresh cluster will be formed which comprise representative from every of the first clusters. In the fresh cluster, each "expert" shares the knowledge which they have acquired and the new cluster produces a result and reveal their combined mastery. Jigsaw lessons offer distinctive prospects for learners to learn from each other and practice modern skills of teamwork and communication in a genuine situation. By using the jigsaw during lessons, it will get student ready for professions in the future.

Jigsaw activity has been a teaching activity that can be used by teachers of all grades in their classrooms. Many educators have adapted and employed the revised versions of jigsaw technique in their classes. Jigsaw technique encourages student participation in a classroom where learners have a critical role for success and this success depends on active cooperation and participation. Using the Jigsaw technique enables access to diverse learning proficiencies and teaches learners course content and cooperative social skills,

2.4 Mathematical Word Problem and Problem Solving

According to Stanic and Kilpatrick (1989), problems have occupied a central place in the school mathematics curriculum since antiquity, but problem-solving has not. Traditionally we use problems as a means of teaching mathematics. More specifically, problems have most often been used as a vehicle to practice facts, rules, formulas, or procedures (Baroody, 1993).

Word problems are defined as the set of problems which in the educational contexts are solved through the application of various elementary arithmetic operations

successively combined with one another until a result is obtained (arithmetic procedure) or through the formulation of equations which are later solved to obtain a result (algebraic procedure) (Cerdan, 2008). Cerdan (2008) claims that it is not the structure of the problem which determines whether it is arithmetic or algebraic but rather the process is undertaken when translating its verbal formulation or algebraic expressions. Solving of mathematical word problems is widely spread across different educational cycles. Word problems are first introduced at the primary school level as with arithmetic operations.

At the senior high school level, a new approach for solving a word problem that is algebra is introduced, and this is a much more effective approach since it can be applied to problems of all kinds. Different theorists have also defined word problems in various ways. Some mathematics educators defined word problems by their structure, appearance and the inbuilt assumptions behind them (Lesh, Post & Behr, 1987). Word problems do have an easily recognizable structure and some assumptions are always made by both students and teachers such as assuming that information not mentioned in the problem statements will not be required for successful problem-solving. According to Boote (1998) a word is defined by its use as a tool rather than by its characteristics. Boote (1998) went on further to say word problems can be useful as a means of illustrating the practical use of an algorithm or a modelling tool in Physics and Statistics. The characteristic features of a word problem are the use of words in the description of the problem and the fact that they refer to real-life context (Kurina, 1989; Semandi, 1995).

Polya (1962) described problem-solving as “finding a way out of a difficulty, a way around an obstacle, attaining an aim which was not immediately attainable” (p166).

Polya (1962) further specified this conception of problems and problem-solving in terms of mathematics: “Our knowledge about any subject consists of information and know-how. What is know-how in mathematics? “The ability to solve problems - not merely routine problems but problems requiring some degree of independence, judgment, originality, creativity” (p VI).

Schoenfeld (1985) on the other hand distinguished between mathematical tasks that are problems and those that are exercises. Schoenfeld (1985) claims that both are important but that students in many high school mathematics classrooms engaged in completing exercises and rarely, if ever, are challenged to solve problems. Lester and Kehle (2003) typify problem-solving as an activity that involves students’ engagement in a variety of cognitive actions including accessing and using previous knowledge and experience. Successful problem solving involves coordinating previous experiences, knowledge, familiar representations, patterns of inference, and intuition in an effort to generate new representations so as to resolve the tension or ambiguity that prompted the original problem-solving activity.

What does it mean for students to organize previous knowledge and experiences to generate new knowledge? It is clear that if students are to be engaged in problem-solving activities, they need to develop a way of thinking, consistent with mathematical practices in which problems or tasks are seen as impasses that need to be examined in terms of questions. Thus, students need to construct their own learning. Mayer and Hegarty (1996) explained problem-solving processes as using different form of knowledge leading to the goal of solving the problem. According to him, the types of knowledge applied in problem solving consisted of:

- Linguistic and factual knowledge - about how to encode statements

- Schema knowledge - about relations among problem types
- Algorithmic knowledge - about how to present distinct procedures, and
- Strategic knowledge - about how to approach problems.

Kroll (1993) said that one of the main reasons for learning mathematics is to be able to use it in solving practical problems. For most students, however, learning how to apply mathematical skills to real life situation is the most difficult task to them. A common difficulty with word problem is trying to do everything at once. It is usually best to approach the problem in stages. But of course, the solution of a word problem depends upon the student's ability to translate the word problem into mathematical equations.

Frobisher (1994) is also of the view that not every question posed in the classroom is a mathematical problem, but rather a problem is a task presented in words with a question posed to define the goal a solver is expected to attain in carrying out the task. Setek (1992) stated that one of the oldest applications of algebra is solving word problems. According to them, word problems require the use of algebra in order to find the solution in a systematic manner as opposed to trial and error. The group enumerated the tools that enhanced problem-solving as patience, reasoning and critical thinking. It is, therefore, necessary for the learner to be given the basic skills needed in translating word problems into mathematical equations.

According to Okpoti (2004) word problem is classified into a well-defined problem and ill-defined problem. To Okpoti (2004), a well-defined problem is the one in which students are provided with four different facts. These are the initial state of the problem, the goal state of the problem, the legal state of the problem, and the operator restrictions which constraints the operators. This means that any word problem that

contains all these facts presented to students to solve is said to be a well-defined problem because almost all the information needed by the students is clearly spelt out for him/her to work with. On the ill-defined problem, he stated that it is the one in which little or no information is provided on the initial state, the operator restrictions or a combination of these. This stands to mean that in an ill-defined problem, the part of the information needed, calls for the student's ability to think logically. The above discussion suggests that students need to be taught algorithmic skills before a word problem is given to them to solve.

Word problems according to Kim, Sharp and Thompson (1994), are to test our ability to use mathematical reasoning in a practical way. This means the solution to a word problem depends upon the student's ability to translate a worded sentence into a mathematical equation, that is we must observe what is given, what is required and what relationship exists among the given facts. Kim, Sharp and Thompson (1994) stressed on the importance of units given in the word problem that is in relation to the solution of the problem. Cooney, Edward and Hendor (1983) defined word problem solving as a process of accepting a challenge and striving hard to solving it. To Cooney, Edward and Hendor (1983), problem-solving is an intellectual skill that must be taught. The teacher is to encourage students in accepting the challenge and guides them to solve it. It is the authors' belief that when an individual understands a principle and has the opportunity to practice its recognition and employment in a variety of situations, then the individual is able to "transfer" the knowledge of the principle in subsequent situations. This means that the students need the technique of accepting the challenge being presented to them.

Polya (1945) in his book "How to solve it?" suggested four phases in problem solving. These phases are:

- Understanding the problem.
- Devising plan to solve the problem.
- Carrying out the plan to solve the problem.
- Looking back at the complete solution to review and discuss it, then extension of the problem.

Leamy (1983) suggested the following approach in translating word problems into mathematical statements;

- Read each problem carefully to find the facts which are related to the missing numbers.
- Represent the unknown number by a variable usually letter.
- Form an equation by translating two equal facts with at least one containing the unknown into algebraic expression and equate one expression to the other.

Leamy (1983) went on further to outline some phrases that can be identified in word translation, and that the signs of operation may assume any one of several meanings. Leamy (1983) cited the following:

- The addition symbol (+) means sum, add, more than, increased by.
- The subtraction symbol (−) means difference, subtract, takeaway.
- The multiplication symbol (×) means product, multiply.
- The division symbol (/) means divide, ratio.

Another school of thought is Miller and O'Neill (2004). To them linear equation can be used to solve many real-world problems. However, with word problems students often do not know where to start. To help organize the problem-solving strategies they offer the following guidelines:

- Read the problem carefully, familiarize yourself with the problem by identifying the unknown and if possible, estimate the answer.
- Assign labels to unknown quantities. Identify the unknown quantity or quantities and represent them by variables. Draw a picture and the formulas.
- Develop a verbal model and an equation in words.
- Write a mathematical equation. Replace the verbal model with mathematical equations using the variables.
- Solve the equation, solve for the variable using the steps for solving linear equations.
- Interpret the result and write the final answer in words.
- Once you have obtained a numerical value for the variable, recall what it represents in the context of the problem. Use the value obtained to write an answer to the word problem in words.

The above discussions stand to mean that students' inability to solve word problems should be the sole responsibility of both the teacher and the student concerned. There are technicalities in word problems which students need to know before equation in word form is given to them. The semantic structure should be explained to the students to help them easily interpret word problems of any form. If students are taught the steps on how to interpret word problems into mathematical statements, then they stand a better chance of solving them correctly.

Teachers of mathematics should, therefore, take the responsibility of taking their students through the required steps and strategies for solving word problems in mathematics for them to acquire the basic steps and skills required.

2.5 Students' Difficulties in Solving Word Problems

According to Newman (1983), difficulty in problem-solving may occur at one of the following phases, namely, comprehension, strategy know-how, transformation process skill and solution. Schoenfeld (1985) suggested four aspects that contributed to problem solving performance. These are the problem solver's, mathematical knowledge, knowledge of heuristics, affective factors which affect the way the problem solver views problem solving, and managerial skills connected with selecting and carrying out appropriate strategies.

Kroll (1993) in a study of problem-solving identified three major cognitive and affective factors; namely knowledge, control and beliefs, and effects that contributed to students' difficulties in problem-solving. Lester (1994) on the other hand emphasized that difficulties experienced during problem-solving could also be caused by the problem solver's characteristics such as traits, disposition, and experiential background. In the early 1970s research tended to attribute difficulties in solving problems to the various task variables such as content and context variables, structure variables, syntax variables and heuristic behaviour variables (Goldin & Mc Clintock, 1979). However, Lester (1994) contended that there was a general agreement that problem difficulty is not so much a function of various task variables but rather a function of characteristics of the problem solver. In other words, the knowledge one possesses, one's disposition and one's experiential background often influence problem-solving performance.

These were also evident in a study conducted in Singapore by Kaur (1995) and Lee (2001). Kaur (1995) indicated that Singapore's students experienced problem-solving difficulties such as:

- Lack of comprehension of the problem posed
- Lack of strategy knowledge
- Inability to translate the problem into a mathematical statement

McGinn and Boote (2003) identified four primary factors that affected perceptions of problem difficulty. These were:

- Categorization - ability to recognize that a problem fits into an identifiable category of problems which run a continuum from easily categorizable to uncategorizable.
- Goal interpretation - figuring out how a solution would appear which run a continuum from well-defined to undefined.
- Resource relevance - referring how readily resources were recognized as relevant from highly relevant to peripherally relevant, and
- Complexity - performing a number of operations in a solution.

McGinn and Boote (2003) suggested that the level of difficulty of the problem depended on the problem solvers perceptions of whether they had suitably categorized the situation, interpreted the intended goal, identified the relevant resources and executed adequate operations to lead toward a solution.

Not all the errors that students do make when solving word problems result from difficulties in representing and translating problem statements. Once the problem has been translated, problem-solving errors can and do still occur and these errors are often due to a bug (Lewis, 1981). Sometimes, students get confused when they try to

formulate a solution for an algebraic word problem. Kieran (1992) says that to solve a problem such as; when 2 is added to 4 times a certain number, the sum is 24; students would subtract 4 and divide by 2 using arithmetic. But solving the problem using algebra would require setting up an equation like $2 + 4x = 24$. There are therefore two different kinds of thinking involved in these two contexts which would sometimes confuse students. In arithmetic, students think of the operations, they use to solve the problem whereas, in algebra, they must represent the problem situation rather than the solving operations. This means apart from the difficulties encountered by students when translating word problems into algebraic language, there are other barriers such as inter interference from other systems, like not understanding the equal sign as a relationship, and other misconceptions in simplifying algebraic expressions.

2.6 Difficulties that Students Encounter

A study by Fuseini and Osei (2019) examined the challenges students in senior high School face in solving word problems in linear equations involving one variable. The action research design was used for the study. This is because the study was about helping students to develop interest so as to overcome their difficulties. Population of the study consisted of students of Tamale Business Senior High School. The purposive sampling technique was used in the study. In all, 2H class made up of seventy (70) students consisting of 44 Boys and 26 Girls were purposively selected for the study. Students in 2H class were selected because they have more difficulties in mathematics than the other classes hence the choice of the class. Test and interview were the main instruments used for the study. Data was analysed using descriptive statistics. The findings revealed that students had difficulties in solving non-routine word problems but could easily solved routine word problems. The researchers concluded that students had difficulties in solving non-routine word problems.

Mathematics teachers should involve students in series of non-routine word problems so as to enhance their approach in solving non-routine word problems relating to linear equations in one variable. The study was limited to only one senior high school which implies that the findings cannot be generalize to cover all Senior high schools in Ghana. Also, the geographical limitations of the work of Fuseini and Osei (2019) that is limited to the city Tamale may imply result generalization is a major challenge hence a gap implying similar study is worth investigating in a different town and Senior high school using jigsaw cooperative learning strategy as a teaching method in mathematics to see whether the findings will conform or deviate to the findings of this study.

Sultan (2014) studied the challenges encountered by students in solving algebra word problems on 34 respondents of the University of Southern Mindanao. The main objective of the study was to identify the challenges encountered by students in solving algebra word problems. A convenience sampling technique was used to identify the respondents of the university. An Informal interview was then conducted after the test was administered. Data were analysed using mean frequency and percentage. Results of the study showed that the challenges encountered by the students were difficulty in translating the word problems to mathematical phrase because they had not learned the language of algebra and simplifying algebraic equation. A major recommendation by the researcher was a further study on this matter regarding strategies or technique that can be use in teaching for improvement of the performance of students in solving algebra word problems hence this current research.

Maanu, Sarpong and Andam (2021) in their study on cooperative learning to investigated the impact of the cooperative learning approach on the performance of level 100 students in mathematics using some selected students from Akrokerri College of Education. Forty-two (42) students were selected from the level 100 students offering Bachelor of Basic Education in the institution. A quasi-experimental research design was used and the samples being grouped into experimental (E) and control (C) groups respectively. A Pre-Test and Post-Test were administered to the groups and the result was analysed using a t-test. The analysis revealed that the experimental group had a mean score that is significantly higher than that of the control group. It was then concluded from the findings that the cooperative approach of teaching and learning employed during the intervention processes helped improve the students' difficulties in solving algebraic linear equations. The researchers recommended that the cooperative learning approach promoted students' participation in the learning process and it must be encouraged by all. The geographical limitations of the work of Maanu et al., (2021) that is limited to the city Akrokerri and a college of education may imply result generalization is a major challenge hence a gap implying similar study is worth investigating in a different town and Senior high school using specifically jigsaw cooperative learning strategy as a teaching method in mathematics to see whether the findings will conform or deviate to the findings of this study.

Kakoma and Gift (2016) examined grade 2 learners' difficulties in solving word problems. Fifteen (15) second grade involved interviews which probed the views of their own difficulties as they tackled word problems. The data were qualitatively analysed using a thematic analysis approach based on categories of difficulty identified from existing literature. Exemplars of transcripts and responses which

showed the children experiencing difficulties were included, as well as the children's opinions on their difficulties. The researchers' interpretation of these findings, including proposed subcategories of difficulty, were also given. The report concluded with suggestions of methods-subject to further research; that teachers may use to help children overcome their difficulties with school mathematical word problems.

Another study by Capone, Filiberti, Lemmo (2021) where they were interested in exploring how primary school students develop in the transition from grade 2 to grade 5. The research based on the hypothesis that some difficulties detected in grade 5 were already predictable in grade 2. Starting from the data collected in grade 5 by the National Standardized Assessment, Capone et al., (2021) carried out a quantitative analysis looking for word problems in which students experienced difficulties. Subsequently, a backward analysis was conducted by the researchers on the grade 2 test of the same cohort of students in order to identify a set of word problems linked with those selected in grade 5 test. The analysis showed the presence of many common difficulties in the two grades. A design was carried out on specific educational activities concerning word problem-solving in grade 2. These activities produced positive changes in the experimental class compared to the control class. Capone et al., (2021) suggested that a previous intervention in grade 2 could allow overcoming future difficulties in word problem text comprehension in grade 5.

2.7 Students Views about Jigsaw Cooperative Learning

Surfaifel, Wanggai, Separ and Umanailo (2021) conducted a study on students' perspective of the cooperative learning method with the jigsaw technique in the Prose studies classroom. A key aim of this study was to change the teacher-centred strategy to student-centred by determining if the jigsaw method had an effect on learners'

perceptions of cooperative learning in the Prose studies classroom. The study adopted a qualitative design where 31 respondents were used as a sample and a purposive sampling technique used. Questionnaires were used for the data collection process. In analysing the data, the researchers used a descriptive qualitative approach.

The students' perceptions collected in this study towards cooperative learning with the jigsaw technique showed that the greatest of the students chose to agree and firmly approved with the questions raised. It means that collaborative learning with the jigsaw technique made students more actively involved in the class. Also, it makes students more comfortable to understand the material which has been taught. From the findings, it can be concluded that collaborative studying with the jigsaw technique assists the learners in understanding the lesson. Surfaifel et al., (2021) suggested that there should be further studies on the aspects of literature such as poetry, essay, or drama using cooperative learning method with the jigsaw technique as conducted in this study. This study used a qualitative research design and semi-structured open-ended qualitative interviews and observations. Thus, a worthwhile direction for future research would be using a quantitative research design or mixed methods in a mathematics classroom using the jigsaw cooperative learning.

Another study by Susanti and Subekti (2020) on using jigsaw strategy in an English reading class investigated teacher's and students' beliefs on jigsaw learning activities for cooperative learning. It was conducted to fill the void in the literature on jigsaw in the second language (L2) instruction seen from teachers' and students' beliefs. Twenty-four students of the English Language Education Department taking Intensive Reading class and the class teacher were involved in this study, employing

observation and semi-structured interviews, the data of which were analysed using Thematic Analysis.

This study used qualitative research methods to gather data from the participants. It was found that even though the jigsaw learning activities seemed to be successful, the phenomenon was not that straight forward as several students reported that they did not optimally show their best efforts in learning independently before class and did not optimally contribute to the discussions either. The study also found three themes related to teacher's and students' views on the implementation of the jigsaw. The students' pre-college learning experiences as passive learners negatively affected the quality of jigsaw conducted in the class. Though jigsaw was reported to be helpful, jigsaw's success heavily depended on individual student's performance and contribution. Despite the students' limitations, teachers' expectations towards the students motivated students to stretch their limits and perform better. Based on the findings, contribution, limitations, and suggested future studies are stated. The use of qualitative methods in the study of Susanti and Subekti (2020) inherently carried the consequence that the findings may be unique to its contexts hence a mixed method approach in a mathematics classroom using the jigsaw cooperative learning.

Utami (2019) studied students' perception on the use of cooperative learning approach. This study was quantitative in nature and the method adopted was a survey study using the questionnaire as the main data. The population for this study was 70 students who had passed all ICT-based courses from the first semester to the fourth semesters of the Department of English Language Education of the Islamic University of Indonesian. The study used questionnaire as the research instrument. The questionnaire was adopted from Wichadee (2005), namely Cooperative Learning

Approach. The researcher adopted the questionnaire and found the reliability of this questionnaire is 0.85. There were 10 questionnaire and it used five-point Likert scale from level 5 (strongly agree) and level 1 (strongly disagree). The data was analysed quantitatively by using Microsoft Excel. The findings of this research were similar to Wichadee (2005) and Hidayati et al., (2018) that students have positive perceptions about cooperative learning, especially for jigsaw activities because they think that jigsaw can improve their communication skills, and teamwork. A major recommendation for this research was the importance of investigating more about how cooperative can help students to achieve learning goal hence a mixed method approach for the current research in a mathematics classroom.

Another study by La Viola and Zainil (2022) aimed to find out students' perception on the use of the Jigsaw technique in learning reading. The design of this study used was the descriptive quantitative approach. The sample used for the study was grade VII students who learn descriptive text at SMPN 7 Padang academic in the year 2021/2022 who were purposively sampled. This research used questionnaire and interview questions as the instrumentations. The researchers found that the implementation of the Jigsaw technique in learning reading had a good response from the students. Students showed positive perception after the researcher calculated the data. The interviewees were given 5-10 minutes to answer the question. The interviews were audio recorded. The questionnaire data were analysed using Microsoft Excel. The researchers counted the percentage and the mean score in analysing the data. The highest score gained from this study for the reading phase was 4.16 or 82.83% while the lowest score for the quiz phase was 3.96 or 79.10%. The researchers concluded that the results of this study could be reference for the teacher to evaluate the teaching technique or method. The students used for the study felt

happy, had no difficulties and chose the Jigsaw technique in their learning reading. In the other words, students' perception of the Jigsaw technique in learning reading was good/positive. The researchers also recommended that teachers can redetermine their teaching techniques or methods that are suitable for students' need which can improve students' motivation.

Ahmed, Melesse and Wondimuneh (2020) conducted a study and sought to find out the perception of students on the cooperative problem-solving approach and consequently on their performance. The researchers adopted a descriptive-survey design for the study. The population of the study consisted of grade 11 high school students in Dangila preparatory high school, Awi-zone, Ethiopia. A purposive sampling technique was used to select the sample size of 105 students of one school from the six preparatory high schools in the zone for the study. The instruments used for the data collection were questionnaire, interview, and focus group discussion. The results of the study showed that cooperative problem-solving learning experiences contributed to social skills growth, critical thinking skills, where positive interpersonal and social relationships became noticeable and more achievement.

Findings further showed that students had a higher confidence level in cooperative problem-solving as compared to working individually. The study was limited to only one senior high school which implied that the findings cannot be generalize to cover all Senior high schools in Ethiopia. This provides a gap implying similar study is worth investigating in a district, municipal, regional or national perspective to ascertain the real effectiveness of the cooperative problem-solving learning specifically jigsaw cooperative learning strategy as a teaching method in mathematics. This poses the gap worth investigating in another country to see whether the findings

will conform or deviate to the findings of this study. Also, the main objective of the study was to find out perception of students on the cooperative problem-solving approach and consequently on their performance which in turn was achieved as revealed by the results of the study. Another critique is that the researchers did not state the theoretical framework that supported their study and also did not state any recommendations for teachers or policy makers in their study.

2.8 Difference between the Performance of Students Taught by Jigsaw Strategy

Yemi, Azid, and bin Md Ali (2018) in their study looked at investigating the effects of jigsaw cooperative learning on students' academic achievement of first year senior secondary school (SS 1) students in Nigeria. The study employed the used of quasi-experimental design. The sample of this study consisted of 80 SS1 students who were selected from a population of 5,901, first year senior secondary one (SS 1) students in Gombe State – Nigeria. The study was carried out in two groups. One of the groups was randomly assigned to the Jigsaw strategy group, and the second group was assigned to the control group, in which the traditional teaching method (Lecture) was applied. The data collected were analyzed using descriptive statistics. The results of the findings indicated that the teaching of mathematics via the Jigsaw strategy was more effective than the traditional teaching method in increasing academic achievement. Additionally, it was further inferred that Jigsaw method increases positive attitudes toward learning the subject. The results further indicated that there was a difference in the mean scores and standard deviations of the treatment and control groups on the pretest and posttest.

A study by Michael, Yakubu and Abdullahi (2022) aimed at finding the effects of Jigsaw cooperative learning strategies on students' interest and performance in social

studies. The study was a quasi-experimental non-randomized pretest - posttest control group design. The target population for this study consisted of all the 2,024 Upper Basic 11 Social Studies students in Wukari Local Government Area of Taraba State, Nigeria during the 2020/2021 academic session. Purposive sampling technique was used to obtain a sample of six schools.

The sample for the study was 74 Upper Basic 11 Social Studies students from the six selected secondary schools. Six intact classes were used for the study. The instrument used for data collection was "Social Studies Interest and Performance Test" (SOSIPT). The researcher trained the teachers in the experimental group on the technique of jigsaw cooperative learning strategy before the treatment. The instrument was pilot tested to ascertain the reliability. The reliability co-efficient alpha was 0.78. Data was analysed using mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 significant level. The result of the study shows that there is significant difference in the mean performance scores of students in Social Studies taught using jigsaw cooperative learning and conventional strategies and there is significant difference in the students' mean interest scores in Social Studies taught using jigsaw cooperative learning and conventional strategies.

The researcher concluded that jigsaw cooperative learning is an effective teaching method, which Social Studies teachers should be encouraged to use and should be implemented in all teachers' education programmes in Nigeria and other African nations. The geographical limitations of the work of Michael, Yakubu and Abdullahi (2022) that is limited to the Wukari Local Government Area of Taraba State, Nigeria may imply result generalization is a major challenge hence a gap implying similar

study is worth investigating in a different country. Though jigsaw cooperative learning strategy as a teaching method was used for the study, the researcher sought to find out if the teaching method will bring about improved performance in a mathematics classroom.

Another study by Rankweteke (2020) indicated the positive effect cooperative learning strategy had on the learners' conceptual understanding of trigonometry. The study by Rankweteke (2020) was qualitative and adopted case study as a research design which was appropriate since it offered an in-depth analysis of one or more events, settings, programs, social groups, or individuals in their natural setting. The study was conducted in Limpopo Province, Capricorn District, Matladi Project High School in the Moletlane Circuit using thirty-one (31) Grade 11 students and their teacher. The data was collected through a semi-structured interview and lesson class observation. Interview questions were designed for the participants as well as an observation guide to help form a record of important information.

The findings from the study showed that the teacher did not highlight the importance of trigonometry to learners. The topic was only introduced, then he continued with the lesson without explaining the importance of the topic in real life. Some learners contented that their difficulties in comprehending trigonometry was as a result of teachers failing to teach in ways they understood. In terms of cooperative learning, the study found that many learners were passively engaged, listening to or watching the teacher, hence the use of the cooperative learning helped to enhance the learners' conceptual understanding of the topic. The gap identified here was that, this study extracted a sample of students and a teacher.

Although the sample was enough to answer research questions posed herein, the findings from this study cannot be generalised to Grade 11 learners and teachers in South Africa. This study also used a qualitative research design and semi-structured open-ended qualitative interviews and observations. Thus, a worthwhile direction for future research would be using a quantitative research design or mixed methods with curriculum advisors, principals and more teachers to provide a more in-depth understanding of the use of cooperative learning in learning in a different mathematics concept.

A similar study by Marhamah and Mulyadi (2013) focused on investigating the effect of jigsaw cooperative learning instruction on the second-year undergraduates' achievement of teaching learning strategy. Undergraduates' opinions about jigsaw cooperative learning instruction were also investigated. The participants of this study were 52 second-year undergraduates in Islamic education department in Islamic University of Jakarta, Indonesia.

The study adopted a quasi-experimental design. A multiple-choice test item was used to measure students' achievement. A pre-test was applied to both experimental (N = 28) and control groups (N = 24) before the treatment in order to identify undergraduates' prior knowledge about "Teaching Learning Strategy" and to determine if there was a significant change in Teaching Learning Strategy from pre-test to post-test for second-year undergraduates. Independent t-test was conducted to compare the prior knowledge test scores for groups and no significant difference was found in terms of mean scores. After the instruction, post-test was administrated to investigate undergraduates' achievement.

The results showed that students in the experimental group, who perceived their instruction as more cooperative and more student-centred, had significantly greater improvement on achievement measures than did the students in the control group. In addition, individual interviews reflected that undergraduates had positive opinion about jigsaw, and they believed jigsaw is an effective cooperative learning technique that promotes positive attitudes and interest develop inter-personal skills. The major findings of this study support the effectiveness of jigsaw learning for students in Indonesia higher education institutions. Though jigsaw cooperative learning strategy as a teaching method was used for the study as well as a quasi-experimental design was adopted for this study, the researcher sought to find out if the teaching method will bring about improved performance in a mathematics classroom.

Nduji, Nwandikor, Keziah and Elejere (2020) in their study determined the effect of jigsaw-based cooperative learning strategy (JBCLS) on senior secondary school students' interest and achievement in Physics. Two research questions were posed and two hypotheses formulated for the study. A non-equivalent control group quasi-experimental research design was adopted for the study. The study was carried out in Agbani Education Zone of Enugu State. A sample size of three hundred and sixteen (316) SS1 physics students from four schools was used for the study. The students in two different groups of the intact classes were taught using jigsaw based cooperative strategy (JBCLS) and lecture method respectively. Physics achievement test (PAT) and Physics interest inventory (PII) were used to collect data. The instruments were trial tested and a reliability index of 0.79 and 0.81 were obtained for the instruments respectively. The research questions were answered using mean and standard deviation and hypotheses tested using analysis of covariance (ANCOVA). The findings revealed that use of jigsaw based cooperative learning strategy was more

superior in enhancing interest and achievement of Physics students than lecture method. Thus, the study recommended adequate training of Physics teachers on the effective use of jigsaw based cooperative learning strategy for innovative teaching. Also, that Physics curriculum planners should include the use of jigsaw based cooperative learning strategy to aid innovative education. The geographical limitations of the work of Nduji et. al, (2020) that is limited to the Agbani Education Zone of Enugu State, Nigeria may imply result generalization is a major challenge hence a gap implying similar study is worth investigating in a different country. Though jigsaw cooperative learning strategy as a teaching method was used for the study, the researcher sought to find out if the teaching method will bring about improved performance in a mathematics classroom.

Another study by Mbacho (2013) sought to address the problem of ineffective instruction by teachers by finding out if the use of Jigsaw cooperative learning Strategy during instruction of Surds and further logarithm in mathematics to form three students had effects on their performance. Surds and further logarithm are topics that are performed poorly in the KCSE. Solomon four non-equivalent control group design was used in the study. The two experimental groups received the Jigsaw cooperative learning strategy as treatment and two control groups were taught using the conventional learning/teaching methods. A simple random sample of four district secondary schools was selected from Laikipia East District. The sample size was 160 students out of population of about 20,000 students in the district. A mathematics achievement test (MAT) was used for data collection. The instrument was piloted in a school which was not used in the study in the Laikipia East District. The instrument used had reliability coefficient of above the required threshold of 0.70. The instrument was validated by education experts from the Department of Curriculum and

Instruction. Data was analysed using t-test to test hypotheses at Coefficient alpha (α) level of 0.05. The findings of this study showed that learners taught using Jigsaw cooperative learning strategy performed better than those taught using conventional learning methods. The results also show that there was no significant difference in achievement of girls and boys when taught using jigsaw cooperative learning strategy.

CHAPTER 3

METHODOLOGY

3.0 Overview

This chapter describes the research process that was used in the study which includes the research design, location of the study, population, sampling procedures and sample sizes, instruments used, data collection procedures, data analysis and ethical considerations for the study are discussed.

3.1 Research Paradigm

A research paradigm encompasses the philosophical and methodological frameworks that shape the way researchers approach their inquiries and interpret their findings. This research was guided by the pragmatist research paradigm which uses mixed method approach and value flexibility in research design.

3.2 Research Approach

The study adopted the mixed method approach where both quantitative and qualitative data were collected.

3.3 Research Design

A research design is an overall plan for collecting data in order to tackle the objectives of the study (Fraenkel & Wallen, 2000). The research design employed for this study was quasi-experimental model. It is a model that allows researchers to answer critical questions about the relationship between variables by determining whether there are significant differences between variables (Butin, 2010). According to Gall, Borg and Gall (2003), a quasi-experimental non-equivalent pre-test and post-test control group research design is the most important research design for investigating cause and effect relationships between two or more variables. Quasi-

experimental is used often in educational research because it is often impossible and sometimes unethical to randomly assign students to settings. In general, the strength of quasi-experimental research lies in its practicality, feasibility and generality.

3.4 Basic Design of the Study

The design comprised two groups; experimental and control groups. The two classes were labelled class A for Control group and class B for Experimental group by a toss of a coin. This ensured that bias was eliminated while giving opportunity to each sample point selected. Both groups were pre-tested before the treatment. This was to ensure homogeneity among the students. The experimental group was subjected to the treatment (jigsaw strategy) while the control group was taught using the traditional method. After the treatment, post test was also administered to both groups to determine their level of achievement and possible change in attitude. The basic design of the study showing how each group were involved is shown in figure below:

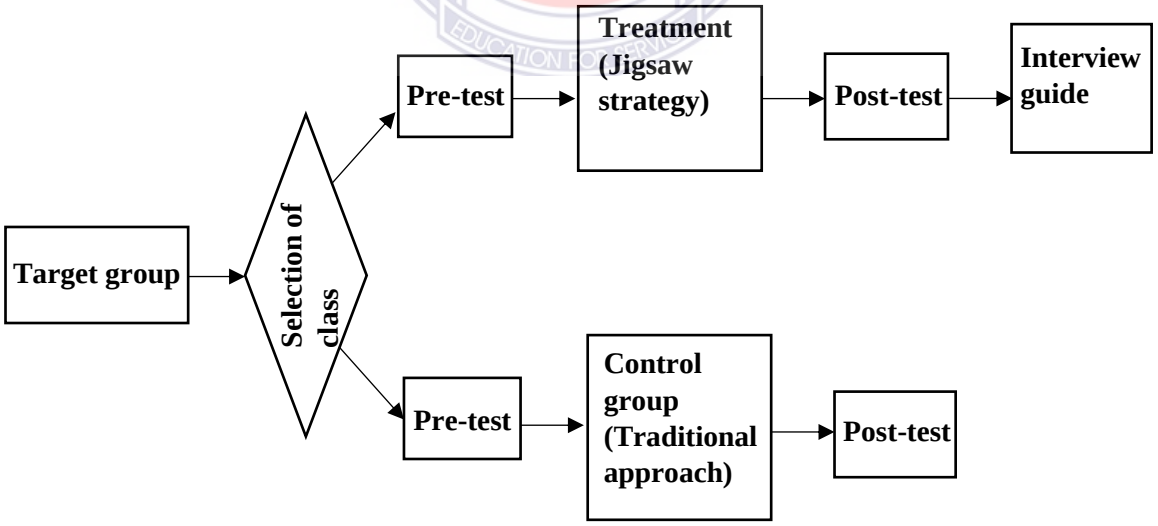


Figure 3.1: Basic design of the Study

It can be seen from the Figure 3.1 that the basic design of the study was in four phases. These phases are pre-test stage, treatment stage, post-test and administering qualitative instruments (i.e. interview guide). The first phase was the pre-test which was carried out simultaneously on all the groups before administering the treatment. The second phase was the treatment stage of which the experimental group were taught using jigsaw cooperative learning strategy while the control group were taught using traditional teaching methods. The third phase was administering the post-test to both groups after the four weeks of treatment. After the respondents go through the fourth phase, the test results were evaluated to determine whether jigsaw strategy as an instructional approach affect student achievement in word problems involving linear equations or not.

3.5 Population

A population in research sense is the complete set of units of analysis that is under investigation (Davis, 2005). The target population for this study was all Senior High School (S.H.S) students in the Ahanta West Municipality of the Western Region of Ghana in the 2021/2022 academic year. The accessible population for this study was nine hundred (900) first year students of St. Mary's Boys' Senior High School, Apowa in the Ahanta West Municipality of which one hundred and sixty-four (164) are day students while seven hundred and thirty-six (736) are boarders.

3.6 Sample and Sampling Technique

The research was conducted in 1 Business A and 1 Science 2 classes which has a population of fifty (50) students and forty-six (46) students respectively. The average age of the classes was seventeen (17) and sixteen (16) respectively. A purposive sampling technique was used to select two classes (1 Business A and 1 Science 2).

Creswell (2009) stated that purposive sampling is employed because of the special characteristics of the school in facilitating the purpose of the research. In purposive sampling, the units of the sample are selected not by a random procedure, but they are intentionally picked for the study because of their distinctive characteristics. The reason for the selection of 1 Business A and 1 Science 2 classes was that all the lessons were taught during the instructional time and the intact classes were used for study so that the concept taught would be beneficial to the class. Further, the usage of the entire class was to avoid disturbance during the school session. The form one classes were used because the topic treated in the study was among the form one topics in the mathematics syllabus for S.H.S and the school would not allow me to teach or reteach this topic in the other forms.

3.7 Research Instruments

Achievement test and semi-structured interview guide were used to collect data. The achievement test was used to collect quantitative data while the interview guide was used to collect qualitative data. The qualitative data and results were used to assist in explaining and assigning reasons for quantitative findings. Each group (control and experimental) was given a pre-test before the treatment. After four weeks, made up of a total of 12-hours treatment lesson (Jigsaw strategy by the researcher) and (traditional teaching approach by the control class teacher) was delivered to each group (control and experimental), a post-test was administered to both groups during the sixth week.

3.7.1 Achievement tests (pre-test and post-test)

Based on the lesson taught and the learning objectives in the Senior High School mathematics curriculum, the items on the teacher-made achievement test were

constructed. The aim of this instrument was to provide a measurement of achievement. The teacher made-achievement test was preferred in this study to other types of tests due to the following reasons: It reflects instruction and curriculum; it is sensitive to student's ability and needs; it provides immediate feedback about student progress; and finally, it can be made to reflect small changes in knowledge (O'Malley, 2010).

The pre-test and post-test each comprised three (3) parts with five (5) questions each. Part 1 required students to write down equations represented by mathematical statements; part 2 required students to write down statements represented by mathematical equations Finally, students were expected to solve all the five (5) questions in part 3 in detail. Learners were expected to spend 60 minutes for the pre-tests and post-tests. Each question in part 1 and 2 had a score of 2 marks, giving a total of 20 marks. Each question in part 3 also had a score of 6 marks, making up a total of 30 marks. In all, a total mark of 50 was awarded for the work. The pre-test administered was used to determine the initial entry points and compare the difference between the experimental and control group before treatment. Post-test was used to measure the students' achievement after the treatment. The items in the achievement tests measured students' ability in the area of knowledge, understanding and application of algebra (See Appendix C and E).

3.7.2 Interview guide

An interview is a tool for particular questions to be proposed by the researcher who manages the line of questioning so as to acquire a certain response (Creswell, 2009). Interviewing is one of the most influential techniques employed in an effort to comprehend an individual's perspective, beliefs and values. As a result of its

interactive nature, interviewing has many benefits over other kinds of data gathering methods such as questionnaire (Best & Kahn, 2003; Legard, Keegan & Ward, 2003). Apart from the achievement test, a semi-structured interview was used to address the research question: "What view do students have on jigsaw strategy in teaching word problem?" According to Bryman and Bell (2007), a semi-structured interview follows a list of concerns and questions that the researcher wishes to cover during a period. The reason for choosing the semi-structured interview technique was basically due to researcher's aim to encourage the interviewees to freely discuss their own views on the jigsaw strategy of teaching word problems involving linear equations. This method with open-ended questions allowed the researcher to adjust his questions depending on the attributes of the specific student and the given type of views they expressed. Semi-structured interviews provide the opportunity to regulate the order of the questions and the respondents have the possibility to expand their ideas and speak in great detail about diverse subjects rather than relying only on concepts and questions defined in advance of the interview (Bryman & Bell, 2007).

In other words, semi-structured interviews are more flexible than standardised methods such as the structured interview or survey. Also, this semi-structured interview was chosen in this study to other qualitative instruments due to the following reasons: interviewees get the opportunity to check what is meant by a question and allows for long and complex responses; it has some flexibility making possible changes in the order of questioning, the questions asked and the topics discussed; it gives chance for probing follow up questioning seeking clarification or further explanation and finally, it provides in-depth inquiry (Merton, Fiske & Kendall, 1996).

However, one general problem when conducting qualitative interviews, with open-ended questions, is that the interview is characterised by the interest and opinions of the interviewer. Semi-structured interviews are rather organized in terms of what issue will be discussed during the interview but the follow-up questions will be depending on the opinions of the interviewer. Another problem that can occur is misunderstandings and misinterpretations of words. This could be no problem within this research since interviews have been conducted in English which students easily expressed themselves in. Nevertheless, in order to increase the reliability of the interview results, the items on the interview guide were strictly followed. Five students were randomly sampled for the semi-structured interview. All interviews were recorded, subsequently transcribed material was also read to the respondents, statements were amended according to the respondents' comments and finally, the material was approved by the interviewees. The semi-structured guide containing 15 items (See Appendix G) was used to elicit information on the students' impressions about the use of the jigsaw strategy to teaching word problems involving linear equations, whether or not they enjoyed learning with the jigsaw strategy and environment, new things they learnt, their challenges and recommendations. This interview helped in assigning and explaining the quantitative result.

3.8 Treatments of Groups

The jigsaw strategy was applied to the experimental group whereas a traditional method of instruction was applied to the control group throughout this study. The approach is described in this section.

3.8.1 Control design: the traditional approach

This term was used in this study to refer to the teaching using chalk and board for teachers; pen and paper for students. The teacher gives the input verbally or writes on

the board and the learners strictly follow the instruction the teacher gives and active participation of the students were not encouraged. The teacher administered traditional instructions on the same contents of the learning task to the learners using the traditionally designed mathematics texts. As typical of the traditional instructional approach, he used lecture method to teach the concept. After introducing and explaining each day's topic, he worked some examples on the chalkboard and gave some exercises to the learners to attempt in their notebooks. He then marked the learners' work and did the corrections on the marker board.

3.8.2 Experimental design: Jigsaw learning strategy

To promote change in the study of word problems, jigsaw strategy-based teaching was prepared by the researcher and used with the experimental group lasting four (4) teaching weeks and two (2) weeks for the pre and post tests. Series of treatment activities were planned by the researcher to improve the understanding of the students in word problems due to the non-performance of the students in the pre-test. The challenges students encountered when translating the word problems into linear equations and vice versa had to be addressed. The activities were therefore put in place and implemented based on the outcome of the pre-test, which revealed that most of the students had problems in the area of understanding the word problems and hence translating them into linear equations before finally solving them.

The first week was used to administer the test items designed for the pre-test. The first step to identify students' difficulties through jigsaw was to listen to what the students found interesting or difficult about word problems in the pre-test. Until this point, the students had not been provided with the level of choice necessary for students' interest and difficulties to develop as a starting point to address their learning needs.

The researcher engaged the students in a roundtable discussion about what they found interesting or enjoyable or difficulties regarding word problems. This process was not easy, as many students had never had a question such as this posed during their schooling. This was challenging for many of the students, who frequently responded with statements such as “I am not sure” or “I have never thought about it” and “Well, I am good at addition, so I guess that’s my favourite.” “Solving linear equations is not difficult for me but then making sense of phrases like twice a certain number confused me a lot I don’t get it”. “The words….in twelve (12) years’ time, and she will be twice as old... “Consecutive number get me confused”.

In the second week, the researcher took learners through the concept of algebraic expressions. Here the learners were taken through how to write mathematical expressions for verbal expressions and vice versa. The introduction stage elaborated on some activities the researcher took to introduce the concept of algebraic expressions. These involved explanations of key terms, asking students questions in order to assess their previous knowledge of the topic. The body comprised of the researcher putting students into groups, giving out example sheets, and engaging students in group discussion. In the concluding stage, the researcher reflected on the topic and gave students class work in order to evaluate the success rate. The researcher finally gave the students homework to bring the lesson to an end. Some of the activities the researcher took students through in the second week were:

Class Setup: the class was divided into small groups, ideally with 4-5 students per group. These groups served as the “base groups” throughout the jigsaw activities.

1. Introduction (Whole-Class Activity):

- The lesson started with an introduction to algebraic expressions, explaining what they are and why they are essential in mathematics. Some basic terminologies used were explained to students (See Appendix M)
- The researcher assisted students to write algebraic expressions from a given word statement. Underline the keywords in each expression, and then write the algebraic expression implied by each phrase below.

2. Base Group Assignments (Expert Groups):

- Each base group was assigned a specific type of word statement to write as an algebraic expression to focus on. For example:

  Group A: 8 times a number decreased by 3

  Group B: Triple a number plus 5

  Group C: A number divided by 4 increased by 11

  Group D: 15 times the sum of a number and 23

Each group was provided with worksheets or problems related to their assigned word statement

3. Expert Group Discussions:

- Students within the expert groups worked together to understand and translate the word statement into an algebraic expression specific to their group.
- Discussions and collaboration among expert group members was encouraged, allowing them to share insights and problem-solving strategies.

4. Returning to Base Groups:

- Students were asked to return to their base groups, where they shared what they learned from their expert group discussions.

- Each student explained the characteristics and simplification methods related to their assigned expression type.

5. Collaborative Practice:

- Within their base groups, students worked collaboratively on algebraic expression problems that encompassed all the types discussed in the expert groups.
- This collaborative practice reinforced their understanding and allowed them to apply different simplification techniques.

6. Presentation:

- Each base group presented their findings to the class, emphasizing the key concepts, challenges, and insights related to the various types of algebraic expressions.
- Students were encouraged to demonstrate the use of the terminologies in translating for each expression.

7. Class Discussion and Reflection:

After the presentations, the researcher facilitated a class discussion where students reflected on the different word statements types and the strategies they learned.

8. Assessment:

Students' understanding was assessed through practice problems that required them to simplify and manipulate various algebraic expressions they had translated.

In the third week, the researcher introduced the learners to the concept of linear equations after a successful lesson on algebraic expressions. The main objectives for the lesson were;

- Construct a formula (or algebraic expression) for a given mathematical statement.
- Find solution sets for linear equations in one variable.

Jigsaw activities for teaching linear equations during the third week are as follows;

Class Setup: the class was divided into small groups, ideally with 4-5 students per group. These groups served as the "base groups" throughout the jigsaw activities.

1. Introduction (Whole-Class Activity):

- Lesson started with an introduction to linear equations, explaining what they are and their significance in mathematics and real-life applications.
- Researcher provided examples of simple linear equations and discussed how to represent them algebraically.

2. Base Group Assignments (Expert Groups):

- Researcher assigned each base group a specific type of linear equation to focus on.

  Group A: One-step linear equations (e.g., $x + 5 = 11$)

  Group B: Two-step linear equations (e.g., $2x - 3 = 7$)

  Group C: Multi-step linear equations (e.g., $4(2x + 1) = 20$)

  Group D: Linear equations with fractions (e.g., $\frac{1}{2}x + 3 = 5$)

- Each group was provided with worksheets or problems related to their assigned equation type.

3. Expert Group Discussions:

- Students within the expert groups worked together to understand and solve the linear equations specific to their group.
- Discussion and collaboration among expert group members was encouraged, allowing them to share insights and problem-solving strategies.

4. Returning to Base Groups:

- Students were asked to return to their base groups, where they shared what they learned from their expert group discussions.
- Each student explained the characteristics of the linear equation type they studied and demonstrated how to solve such equations.

5. Collaborative Practice:

- Within their base groups, students worked collaboratively on solving linear equations that encompassed all the types discussed in the expert groups.
- This collaborative practice reinforced their understanding and allowed them to apply different solving methods.

6. Presentation:

- Each base group presented their findings to the class, emphasizing the key concepts, challenges, and insights related to the various types of linear equations.
- Students were encouraged to demonstrate the solving process for each equation type.

7. Class Discussion and Reflection:

After the presentations, the researcher facilitated a class discussion where students reflected on the different linear equation types and the strategies they learned.

8. Assessment:

Students' understanding was assessed through practice problems that require them to solve various types of linear equations.

The fourth week involved the researcher introducing learners to the concept of word problems using the appropriate terminologies in order to address the difficulties that were mentioned by the students and were identified by the researcher. The researcher based the teaching on the observations made during the roundtable discussion with the students and also from the result of the pre-test conducted. The researcher introduced the students to the use of jigsaw strategy in word problem. Activities that the marked the fourth week were;

Class Setup: the class was divided into small groups, ideally with 4-5 students per group. These groups served as the "base groups" throughout the jigsaw activities.

1. Introduction:

The researcher started with an introduction to the importance of solving word problems involving linear equations and their real-world applications. The researcher assisted students to extract or list the variables or keywords/clues in a given word problem. (See Appendix N)

2. Base Group Assignments (Expert Groups):

- Each base group was assigned word problem to translate into linear equations and solve. For example:

  Group A: Ama is eight years less than twice Appiah's age. The sum of their ages is forty. How old is Ama?

Group B: Kwesi, Ama and Adwoa shared GH¢ 720.00. Ama received twice as much as Adwoa and Kwesi received three times as much as Ama. How much did each receive?

Group C: The sum of three consecutive numbers is 75. Find the numbers.

Group D: The area of a square land is 81 m^2 . Find the perimeter of the land.

- Each group was provided with worksheets or problems related to their assigned word problem.

3. Expert Group Discussions:

- Students within the same subtopic groups (expert groups) were made to work together to understand and solve the specific type of word problems assigned to them.
- Discussion and collaboration among expert group members was encouraged, allowing them to share insights and problem-solving strategies.

4. Returning to Base Groups:

Students were made to return to their base groups, where each member became an "expert" on their assigned type of word problem.

5. Cooperative Learning:

Within their base groups, students took turns explaining the concepts, strategies, and solutions for their assigned types of word problems. This sharing helped each member understand various problem-solving approaches.

6. Problem Solving:

- Students were provided with word problems that encompassed all the types discussed in the expert groups.

- Base groups were encouraged to collaboratively solve these problems, applying the knowledge gained from their expert group discussions.

7. Presentation:

Each base group presented their findings and problem-solving approaches to the class, emphasizing the key concepts, challenges, and insights related to the various types of word problems involving linear equations.

8. Class Discussion and Reflection:

After the presentations, the researcher then facilitated a class discussion where students reflected on the different types of problems, the strategies they learned, and the relevance of linear equations in real-life scenarios.

9. Assessment:

Students' understanding of word problems that required them to apply their knowledge of linear equations to solve practical situations was then assessed

In the fifth week, the researcher engaged learners to solve more word problems involving linear equations as well as conducting a brief revision on the concepts learnt during the entire intervention process.

In the sixth week, the students went through another set of questions designed by the researcher, to ascertain their understanding of the concept of word problem (Post-Test).

3.9 Validity and Reliability of the Instruments

The validity of a test instrument is the extent to which the items in an instrument measure what it is set to measure. Validity is the exactness and precision of deductions based on the findings from the research (Mugenda & Mugenda, 2003). If a

test does not serve its intended function ell, then it is not valid. One of the most important concepts used to estimate what it was supposed to measure about a research instrument is validity (Johnson & Christensen, 2019; Saunders, Lewis & Thornhill, 2009; Fraenkel & Wallen, 2009). The other concept used together with validity to assess stability of an instrument is reliability. The consistency of responses can also be evaluated through it (Fraenkel & Wallen, 2009). In order to ascertain the content validity and reliability of the instruments used, the researcher consulted, three (3) lecturers in the Mathematics Education Department of the University including my supervisor to review the test item, evaluate whether the items were relevant to the research questions.

Their suggestions helped to establish the face and content validity of the items. Hopkins (2000), expresses precision as validity and reliability. He explains that validity represents how well a variable measure what it is supposed to measure and reliability as how consistent the measure is on a retest. The items were piloted in a sister school in the municipality, Sankor Senior High School where thirty (30) first year students were used. One of the advantages of conducting a pilot study is that it might give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated (Van Teijlingen, Rennie, Hundley & Graham, 2001). The feedback of the pilot study helped to improve the quality of the test instruments in terms of content coverage content validity and reliability. The test yielded a reliability coefficient of 0.74 using Cronbach's Coefficient Alpha test. According to Mugenda and Mugenda (2003), the coefficient is high when its absolute value is greater than or equal to 0.7: otherwise, it is low.

A high coefficient implies a high correlation between variables indicating a high consistency among the variables. No changes were deemed necessary in instruments because the researcher realized that questions students could not answer were not due to the ambiguity of questions but due to their low conceptual knowledge.

The semi-structured interview guide was tested with the thirty (30) first year students from the sister school in the municipality, Sankor Senior High School who had similar characteristics before applying it to the sample of five (5) students who were randomly selected for the main study. The entire interview lasted 45 - 60 minutes.

3.10 Data Collection Procedure

The research instruments were administered personally by the researcher to the respondents. A consent letter was attached to the introductory letter duly signed by the Head of the Mathematics Education Department at University of Education, Winneba was given to the Headmaster of St. Mary's Boys' Senior High School, the participating school. The headmaster willingly agreed to the request and gave the researcher an acceptance letter. The acceptance letter opened the gate for data collection. The introductory letter and the acceptance letters are presented in Appendix A and B. A date was then fixed for the commencement of the study. A week before the main study, the pre-test was administered, marked and analysed to determine the entry level of each group, readiness and difficulties students faced in solving word problems.

The main study took four weeks. Each week the researcher and the facilitator met the students in each class (control and experimental groups) twice for lessons, subjecting the experimental group to the jigsaw strategy and the other to the traditional approach. The groups of students were taken through the treatment. Lessons were designed on

word problems. During the teaching and learning stage, students were given one or two assessment questions in class to assess their short-term learning in each class lesson and were done for both control and experimental groups. These class exercises were marked by the researcher. Although, the scores in the class exercises were not added to the final scores of the post-test for the data analysis, yet the class exercises helped them in the post-test. The data was in the form of pre-test and post-test each lasted for 1 hour. After the administration of the post-test in the last week, a 20 minutes interview was also conducted with five (5) students from the treatment group to find out their views and perceptions about jigsaw strategy. The interviewees were assured of confidentiality and also given code names in order to prevent the exposure of their identities. Prior to each interview session, the interviewees and the researcher agreed on the time and venue of the interview. The permission of each interviewee was also sought before the interview sessions were recorded.

3.11 Data Analysis Procedure

The software that was used for data analysis was the Statistical Package for Social Science (SPSS). The data entries were done by the researcher in order to check the accuracy of the data. Data were cleaned before running any analysis. Cleaning the data helped the researcher to get rid of errors that could result from coding, recording, missing information, influential cases or outliers.

The first research question was analysed using the results of the pre-test with the aim of finding out the difficulties students encountered in Parts 1 and 2 of the test to translate word problems to linear equations and vice-versa. The researcher also made an in-depth analysis of the students' responses in the show working or constructed response section of the test in order to identify their difficulties in solving a word

problem. The various difficulties encountered by students were analysed using percentages, thus; attempting but demonstrating misunderstanding of the problem, attempting and unable to translate problem into equation(s), attempting but fail to solving the equation to reach the solution and attempting to solve the equation but failing to use the right methods or making errors.

The second research question was analysed using the data from the interview collected from the five (5) students in the experimental group after the post-test to answer the research question "What view do students have on jigsaw strategy in teaching word problem?" The interview guide which focused on student' experiences and opinions on the use of jigsaw strategy instruction and reflected their views about their participation in the lesson. All interviews were audio-taped, transcribed and analysed also, verbatim quotations were used to support the discussions.

The third research question was analysed using descriptive statistics of the achievements of the students in the control and experiment groups before and after the intervention. The scores obtained from pre-test and post-test for experimental group was compared in terms of mean scores and standard deviation. Inferential statistics using a paired sample t-test at coefficient alpha level of 0.05 was used in order to find out whether there was any significant difference before and after the implementation of jigsaw strategy in the mathematics class. An independent sample t-test was also used to find out whether there was a significant difference between the post test scores of both the control group that was taught using the traditional method and the experimental group that was taught using the jigsaw strategy.

3.12 Ethical Considerations

Ethics is expected to be taken into account for any research being conducted. Ethical consideration involves a set of moral principles that should guide the behaviour of a researcher towards respondents and other researchers (De Vos, 2002). In view of this, necessary approval-seeking steps were taken to get the research acknowledged by all concerned stakeholders before the execution of the research activities. Protection of participants and their responses were assured by obtaining informed consent, protecting privacy and ensuring confidentiality. In doing this, the description of the study, the purpose and the possible benefits were mentioned to participants. The researcher permitted participants to freely withdraw or leave at any time if they deemed it fit. As a way of preventing plagiarism, all ideas, writings, drawings and other documents or intellectual property of other people were referenced indicating the authors, title of publications, year and publishers. In the case of an unpublished document, permission was sought from the owners.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the analysis and discussion of findings of the study that investigated the use of jigsaw co-operative learning strategy as a tool to address senior high school students' difficulties in solving word problems involving linear equations. Data was collected using pre-test, post-test and interview guide. The data obtained were organized and presented using descriptive statistics including frequency tables, standard deviation, minimum and maximum scores and means; inferential statistics including independent sample t-test. The findings were analysed using the literature noting whether these are consistent with or divergent from the existing body of knowledge. Findings were presented under each research question posed in Chapter 1 as follows:

1. What difficulties do students encounter in translating word problems into linear equations and vice versa?
2. What are students' views on jigsaw strategy in teaching word problem?

H_0: There is no significant difference between the performance of students taught by jigsaw strategy and those that are taught using the traditional approach.

4.1 Demographic Characteristics of the Participants

The number of students who participated in the control and experimental groups of the study were ninety-six (96) students, forty-six (46) students in the control group and fifty (50) students in the experimental group. The participants used for the study were all males since the accessible population was a boys' school. The average age of

the students in both control and experimental groups was seventeen (17) and sixteen (16) years respectively.

4.2 Research Question 1

What difficulties do students encounter in translating word problems into linear equations and vice versa?

In an attempt to answer research question 1, the researcher analysed the results of the pre-test with the aim of finding out the difficulties students encountered in the test in translating word problems to linear equations and vice versa. The researcher also made an in-depth analysis of the students' responses in the show working or constructed response part of the test in order to identify their difficulties in solving a word problem. The difficulties were categorized and discussed under the following headings:

- students attempting but demonstrating misunderstanding of the problem
- attempting and unable to translate problem into equation(s)
- students attempting but fail to solving the equation to reach the solution
- students attempting to solve the equation but failing to use the right methods or making errors.

4.2.1 Students attempting but demonstrating misunderstanding of the problem

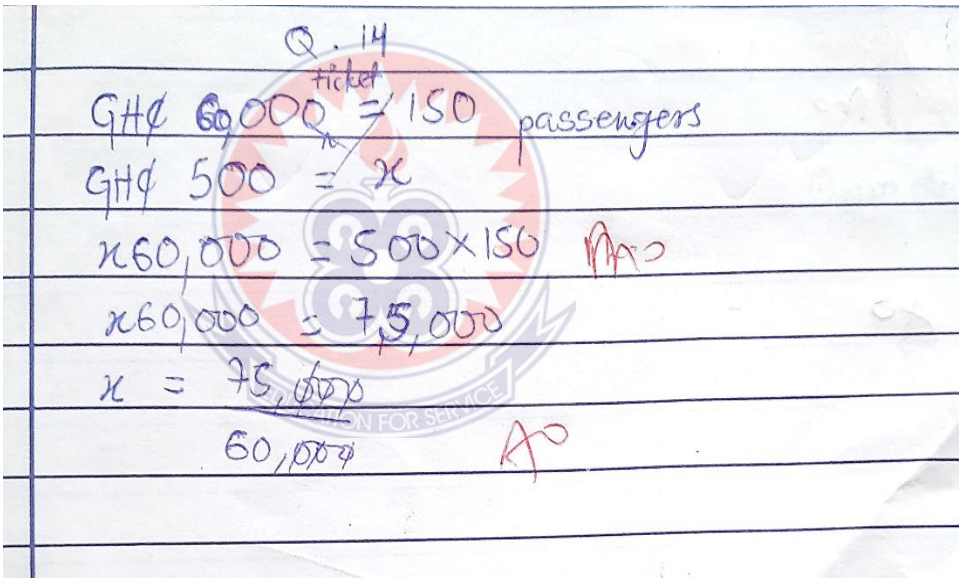
Table 4.1 presents the distribution of students attempting but demonstrating misunderstanding of the problem. After critically reviewing students' responses, the researcher found out that some students demonstrated misunderstanding of the problem.

Table 4.1: Distribution of students attempting (N = number of students) but demonstrating misunderstanding of the problem

Item	Attempted question (N = 96)	Understanding the problem			
		Have Difficulty		Have no difficulty	
		N	%	N	%
(11) The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?	96	55	(57.3)	41	(42.7)
(12) The sum of four consecutive odd numbers is thirty-two. What are the numbers?	96	75	(78.1)	21	(21.8)
(13) Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?	96	80	(83.3)	16	(16.7)
(14) Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?	96	90	(93.8)	6	(6.2)
(15) A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.	96	93	(96.9)	3	(3.1)

In all, the students were required to solve five (5) word problems involving linear equations. The results as illustrated in Table 4.1 revealed that all students attempted all the questions but not all were able to demonstrate an understanding of the problem. For question 11, only 42.7% (N = 41) of students demonstrated a clear understanding of the problem. For questions 12 and 13, only 21.8% (N = 21) and 16.7% (N = 16) of students respectively were able to demonstrate a full understanding of the word problems. For questions 14 and 15 which involved multiple steps and required higher critical thinking, only 6.2% (N = 6) and 3.1% (N = 3) of students respectively were able to demonstrate understanding. These findings revealed that an average of 81.9%

of students do not understand the problem they were asked to solve. Understanding the problem, the first step in problem-solving, according to Polya (1945), is a major difficulty for majority of students. They cannot comprehend the requirements of the problem and seem to lack the mathematical experiences needed to understand the problem (see Appendix J) for the graphical illustration of students attempting but demonstrating misunderstanding of the problem). Sample of students' work 1 shows the response to question 14 showing a complete lack of understanding of the problem. It can therefore be said that understanding of the problem is one of the students' difficulties in solving word problems involving linear equations.



Sample of students' work 1

4.2.2 Students attempting and unable to translate word problem into linear equation(s)

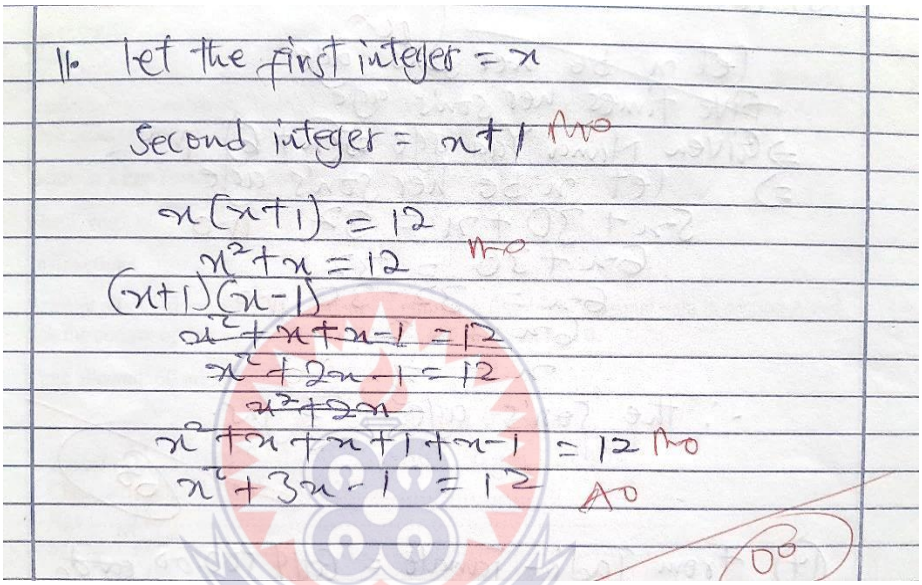
The distribution of students attempting and unable to translate word problems into linear equation is presented in Table 4.2

Table 4.2: Distribution of students attempting and unable to translate word problem into linear equation(s) (N = number of students)

Item	Attempted question (N = 96)	Translating the word problem			
		Have Difficulty		Have no difficulty	
		N	%	N	%
(11) The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?	41	10	(24.4)	31	(75.6)
(12) The sum of four consecutive odd numbers is thirty-two. What are the numbers?	21	6	(28.6)	15	(71.4)
(13) Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?	16	7	(43.8)	9	(56.2)
(14) Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?	6	4	(66.7)	2	(33.3)
(15) A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.	3	0	(0)	3	(100)

The results in Table 4.2 suggest that, on the category of translating a word problem into linear equation, about 41 students attempted question 11. Out of this number, 75.6% (N = 31) of students successfully translated the given problem into the linear equation while the remaining 24.4% (N = 10) attempted but were unable to do it right. With regards to question 12, only 21 students made an attempt and 71.4% (N = 15) had it right while the remaining 28.6% (N = 6) had it wrong. Moving on to question 13, only 16 students made an attempt to translate the word problem into linear equation and 56.2% (N = 9) of them did it successfully.

Interestingly, only 6 students attempted question 14 while 3 students attempted question 15. Of the 6 students that attempted question 14, only 33.3% (N = 2) did it right while all the 3 students that attempted question 15 had them right (see Appendix J for the graphical representation students attempting and unable to translate problems). Sample of students' work 2 shows the response of students who attempted and unable to translate the problem into a linear equation.



Sample of students' work 2

In answering question 11, the student was not able to translate the word problem into a linear equation. It can be seen that the student understands the concept but he had difficulty in writing the correct equation that model the problem.

4.2.3 Students attempting but fail to solve the equation to reach the solution

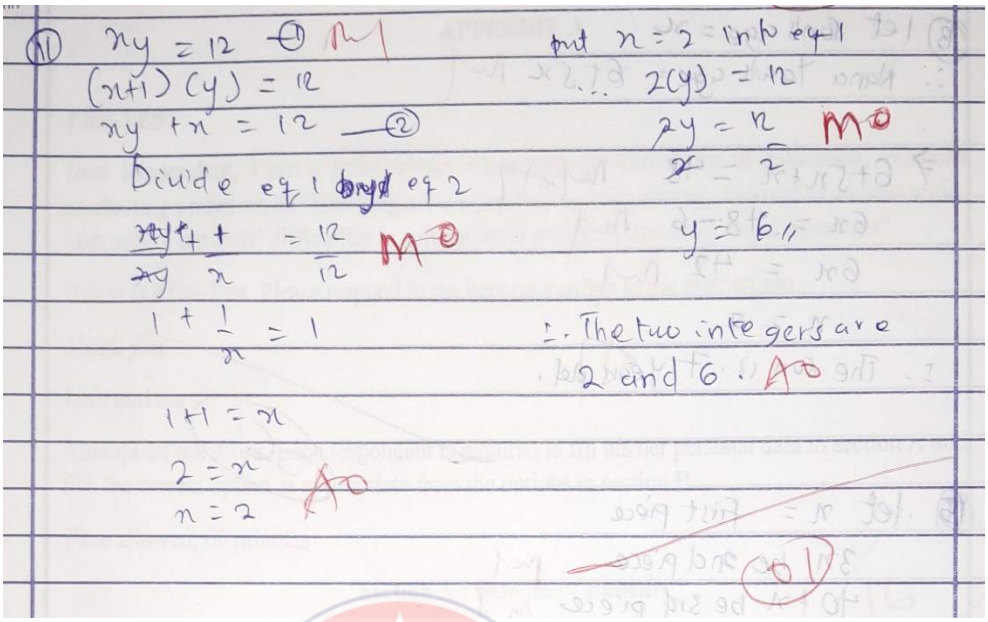
Table 4.3 shows the distribution of students attempting but failing to solve the resulting equation from the problem. The researcher identified a group of students who successfully translated the problems into linear equations but failed to solve them.

Table 4.3: Distribution of students attempting but failing to solve the equation to reach the solution (N = number of students)

Item	Attempted question (N = 96)	Solving the problem			
		Have Difficulty		Have no difficulty	
		N	%	N	%
(11) The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?	31	10	(32.3)	21	(67.7)
(12) The sum of four consecutive odd numbers is thirty-two. What are the numbers?	15	6	(40)	9	(60)
(13) Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?	9	3	(33.3)	6	(66.7)
(14) Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?	2	1	(50)	1	(50)
(15) A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.	3	0	(0)	3	(100)

A careful look at Table 4.3 revealed that 31 students attempted to solve the equation in question 11 and 67.7% (N = 21) of them did that successfully. For question 12, 15 students made the attempt to solve the resulting equation out of which 60% (N = 9) were able to solve the equation right. Moving further to question 13, only 9 students attempted to solve the equation and 66.7% (N = 6) of them were able to solve the equation successfully. 2 students attempted question 14 and had 1 had it wrong whereas 3 students made an attempt on question 15 and they were all able to solve the equation (see Appendix J for the graphical representation of students attempting but failing to solve the equation to reach the solution).

Sample of students' work 3 shows the response of students who attempted but failed to solve the equation.



Sample of students' work 3

It is observed that the student was able to translate the word problem into a linear equation. However, the student had difficulty in solving the resultant equation. This revealed one of the difficulties students face as they solve word problems. The findings are consistent with WAEC (2012) Chief Examiner's Report which indicated that students' performance in WASSCE Core Mathematics, most students avoided the questions on word problem and the few who attempted it; many were unable to solve the problem accurately because they were not able to write correct equation needed to solve the problem.

4.2.4 Students attempting to solve the equation but failing to use the right methods or making errors

The distribution of students attempting but failing to use the right methods is presented in Table 4.4 After a critical review of students' responses, the researcher identified a group of students who attempted but failed to use the right methods.

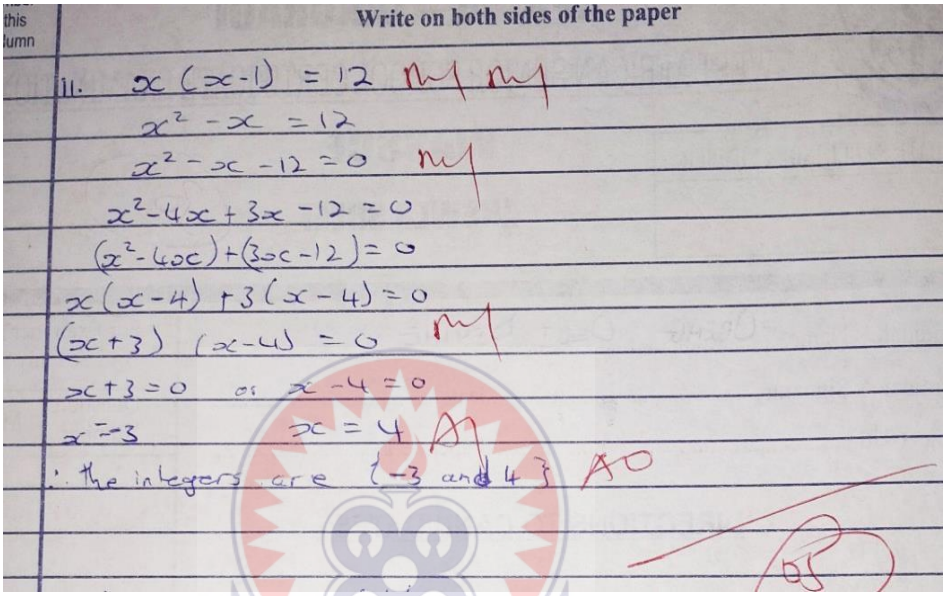
Table 4.4: Distribution of students attempting but failing to solve the equation to reach the solution (N = number of students)

Item	Attempted question (N = 96)	Obtaining solution			
		Have Difficulty		Have no difficulty	
		N	%	N	%
(11) The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?	31	13	(61.9)	8	(38.1)
(12) The sum of four consecutive odd numbers is thirty-two. What are the numbers?	15	6	(66.7)	3	(33.3)
(13) Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?	9	5	(83.3)	1	(16.7)
(14) Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?	2	0	(0)	1	(100)
(15) A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.	3	0	(0)	3	(100)

In Table 4.4 the researcher further sorts to find out the students who attempted to solve the equation but failed to use the right methods to reach a solution. It was observed that out of the 31 students who attempted to solve question 11, only 38.1% (N = 8) were able to reach a solution for the equation using the right methods. For question 12, out of the 15 students who made the attempt, 33.3% (N = 3) successfully arrived at a solution for the equation using the right methods. Question 13 had only 9 students attempting to solve the equation. Out of these, only 1 student obtained the right solution for the equation. Only 1 out of the 2 students that attempted to solve question 14 arrived at the solution whereas the 3 students who attempted question 15

successfully obtained the required solution (see Appendix J for the graphical illustration of students attempting but failing to use the right methods to reach the solution for the equation).

Sample of students' work 4 shows the response of students who attempted but failed to use the right methods to reach the solution for the equation.



Sample of students' work 4

The sample shows a typical example of students attempting to solve the equation but failing to use the right methods to reach the required solution. It is observed that the student understood the concept and successfully translated the problem into a linear equation. The student solved the equation but failed to use the right method to reach the solution as required. Again, this demonstrates one of the difficulties students face as they solve word problem.

4.3 Research Question 2

What are students' views on jigsaw strategy in teaching word problem?

In order to find out the authenticity of the use of jigsaw strategy in learning of word problems involving linear equations, the researcher interviewed five (5) students who

were randomly selected to elicit for their views. There were fifteen (15) items on the interview guide which focused on students' views of the use of jigsaw strategy and reflected their views about their participation in the lesson. All interviews were audio-taped, transcribed and analysed. Through the interviews a number of themes emerged from the students' responses. These themes are discussed below.

4.3.1 The approach makes word problem learning more interesting and exciting

The student participants were also asked to describe how the use of jigsaw strategy aid their learning of word problems. It was evident from the responses that, four (4) participants accepted that the use of jigsaw strategy makes learning more interesting and exciting since it helps students to learn in a more meaningful way. Some of the students commented that:

> *"It helps me to know how data are collected from a given story and equations are formed since word problems mostly deal with story problems. In this way I am able to learn word problem in a simpler way" (Interviewee 1).*

> *"In fact, at first, I was finding it difficult to understand how to deduce data from the given story I did not understand how to form equation from it but now the approach has helped me to learn word problem in a more meaningful way" (Interviewee 2).*

> *"Truly at first, I was finding it difficult to form an equation to determine the value of an unknown when given a linear equation word problem question. I did not feel interested learning it but now the approach has helped me to learn and in a more meaningful way making it an interesting concept for me" (interviewee 4).*

> *"I used to dodge linear equations word problem questions. However, with the help of jigsaw strategy I have realized that linear equation word problem is very simple and interesting" (interviewee 5).*

4.3.2 Jigsaw cooperative learning strategy helps facilitate easy learning and understanding of word problems involving linear equations

The participants were also asked to share their views with the researcher on how the use of jigsaw strategy will help improve their performance in mathematics. The five

(5) student participants responded that the use of jigsaw cooperative learning strategy will help increase their academic performance particularly in mathematics since it helps them to understand lessons well. The students therefore expressed the need for their teachers to use jigsaw cooperative learning strategy during mathematical lessons. This was confirmed by one of the participants who said that:

> *"Yes, because it helps easy understanding of word problems involving linear equations" (Interviewee 1).*
>
> *"Oh yes because it helps us to share ideas and also helps us to teach ourselves" (Interviewee 2).*
>
> *"Jigsaw strategy should be the way forward because it burdens us to be responsible for our own learning so we have to spend additional time to research for information to solve a problem" (Interviewee 3).*
>
> *"This teaching method is very interesting. It helps you to share ideas with your mates" (Interviewee 4)*

Responses from the students suggest that, when teachers do actively involve learners in the learning process, they learn better.

4.3.3 Jigsaw strategy makes lesson practical

The researcher tried to find out from the students if they would like to use jigsaw cooperative learning strategy to learn word problems involving linear equations and explain the reasons behind their decision. From the response, it was evident that the five (5) students expressed interest in the use of jigsaw cooperative learning strategy to learn because it makes lesson practical and helps easy understanding of word problems involving linear equations. For instance, one of the respondents' commented that:

> *"Yes, the reason why I am saying this is that using the approach to learn word problems involving linear equation makes lessons more practical and this will make me get general understanding of every concept" (Interviewee 2)*

> *"If my JHS mathematics teacher had used jigsaw strategy to teach us I would have understood the topic without difficulty" (Interviewee 3).*
>
> *"This method of teaching is very practical in nature. We are more involved in the learning process than the one we used to be taught by" (Interviewee 5)*

The views from students suggest that, when mathematics is taught in a more practical way, it becomes easier to understand every concept.

4.4 Research Question 3

H_0: There is no significant difference between the performance of students taught by jigsaw strategy and those taught using the traditional approach.

The third research question sought to determine the effect jigsaw strategy has on students' achievements in word problems involving linear equations. To do this, the descriptive statistics of the achievements of the students in the control and experimental groups before and after the intervention were examined. Table 4.5 shows the descriptive statistics of scores obtained by students in the control and experimental groups.

Table 4.5: Descriptive statistics of students taught with jigsaw strategy and those taught without it

Group	Test	Mean	Std Deviation
Control	Pre-Test	12.02	2.499
	Post-Test	14.24	3.212
Experimental	Pre-Test	13.94	3.067
	Post-Test	22.98	6.352

Table 4.5 compares the pre-test and post-test results of the students within the experimental group. In the experimental group, the results showed an improvement in students understanding of word problem involving linear equation in the post-test.

The mean score of students in the pre-test was 13.94, while that of the post-test was 22.98, an increase of 9.04. With regards to the control group, the mean score of students in the pre-test was 12.02, while that of the post-test was 14.24, an increase of 2.22. This is an indication that in the post-test, every student's performance slightly increased in the control group.

To ascertain whether or not the difference observed in the means are statistically different, a paired samples T-test was conducted to test the null hypothesis that there is no significant difference between the performance of students taught by jigsaw strategy and those taught using the traditional approach. Table 4.6 presents the results of the paired sample t-test on the pre-test and post-test performance of students taught with jigsaw strategy.

Table 4.6: Results of the paired sample T-test on the pre-test and post-test performance of students in the experimental and control groups

Group	Test	Mean	Std. Deviation	Std. Error Mean	T	df	Sig. (2-tailed)
Control	Pre-Test	2.217	3.299	0.486	4.558	45	0.000
	Post Test						
Experimental	Pre-Test	9.040	6.731	0.952	9.497	49	0.000
	Post Test						

With regards to the experimental group, the paired sample t-test results showed the mean score difference (M = 9.040, SD = 6.731) between the post test and pre-test was statistically significant. This was done to evaluate the effect jigsaw strategy on students' achievement in word problems involving linear equations. The results from Table 4.6 indicated a statistically significant increase in the students' achievement from the pre-test (M = 13.94, SD = 3.067) to the post-test (M = 22.98, SD = 6.352), t

(49) = 9.497, $p < 0.05$. The effect size, measured by Cohen's d was found to be 2.879 with a correlation coefficient of 0.821 indicating a large effect size (Cohen, 1988) (See Appendix K).

This showed a very large effect on student success in solving word problem using the jigsaw strategy. Also, the results implied that after the students had been taken through the intervention, they improved slightly in their understanding and achievement of the concept on word problems involving linear equations. Thus, jigsaw strategy had a positive impact on the students' achievement in word problems involving linear equations.

Similarly, a paired sample t-test was employed to compare the pre-test and post test scores for the students taught with traditional teaching approach (control group). The paired sample t-test was examined to find out if the mean score difference (M = 2.217, SD = 3.299) between the post-test and pre-test of the control group was statistically significant. This was done to assess the effect of traditional method on students' achievement in word problems. The results from Table 4.6 indicated that the effect was statistically significant increase in the students' achievement from the pre-test (M = 12.02, SD = 2.499) to the post-test (M = 14.24, SD = 3.212), t (45) = 4.558, $p < 0.05$. In addition, the effect size, measured by Cohen's d was found to be 0.460 with a correlation coefficient of 0.224 indicating a small effect size (Cohen, 1988) (See Appendix K).

To ascertain whether or not the difference observed in the means are statistically different, an independent sample t-test was conducted to test the null hypothesis that there is no significant difference between the performance of students in the post test taught by jigsaw strategy and those taught using the traditional approach. Table 4.7

presents the results of the independent sample t-test on the control group post test performance and experimental group post-test performance of students.

Table 4.7: Results of the independent sample t-test on the post test performance of students in the experimental and control groups

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
POST TEST	Equal variances assumed	18.305	0.000	-8.395	94	0.000	-8.741	1.041	-10.808	-6.674
	Equal variances not assumed			-8.607	73.819	0.000	-8.741	1.016	-10.764	-6.717

Table 4.7 shows that there was a significant difference between the performance of students in the experimental group taught by jigsaw strategy (M = 22.98, SD = 6.352) and that of those in the traditional group taught by the conventional method (M = 14.24, SD = 3.212, t(94) = 8.395, p = 0.0001).

4.5 Discussion of Results

The first research question aimed at identifying the difficulties SHS students encounter in translating word problems into linear equations and vice versa. After a careful analysis of the pre-test, the researcher came out with four major categories of difficulties namely:

- students attempting but demonstrating misunderstanding of the problem
- students attempting and unable to translate problem into algebraic model or equation(s)

- students attempting but fail to solving the equation to reach the solution
- students attempting to solve the equation but failing to use the right methods or making errors.

The findings revealed that an average of 81.9% of students did not understand the problem they were asked to solve. Understanding the problem, the first step in problem solving, according to Polya (1945), is a major difficulty for most students. They cannot comprehend the requirements of the problem and seem to lack the mathematical experiences needed to understand the problem.

Concerning students attempting and unable to translate a problem into linear equations, 87 out of the 96 students attempted to translate a word problem into a linear equation. The findings revealed that an average of 32.7% of students had difficulty in translating a word problem into linear equations.

The third difficulty identified was students attempting but failing to solve the equation to reach the solution. It was found out that only 60 students attempted to solve the equation resulting from the translation of word problem into a linear equation.

The last difficulty identified was students who attempted but failed to use the right methods reach a solution for the equation. It was revealed that out of the 60 students who attempted to solve the equation, only an average of 42.4% of students reached a solution for the equation using the right methods.

These findings are consistent with a study by Macgregor and Stacey (1997) who noted that one of the difficulties for learners is how to interpret these symbols correctly. Macgregor and Stacey (1997) were of the view that, mathematical ideas often need to be reformulated before they can be represented as an algebraic statement

and symbolic notation. The rules for interpreting and manipulating mathematical symbols are not always in accord with the way relationships are conveyed through the English language. Lannin (2005) supported this argument by stating that learners often fail to understand the meaning linked with the formal symbols they use including the operational symbols.

The researcher came up with an intervention to aid students in solving word problems involving linear equations in order to minimise the students' difficulties in an experiment in which one group was treated with the jigsaw cooperative learning strategy and the other with traditional approach. The outcome from the intervention showed that there was a statistically significant difference between the mathematics achievement mean scores of the experimental group and that of the control group [$t(49) = 9.497$, $p < 0.05$]. This finding implied that the experimental group performed better than the control group in the word problem achievement test. This implies that when students are taught using jigsaw cooperative learning strategy, their performance would improve better than students taught using traditional method. Using jigsaw strategy through group work and discussion, to solve word problems involving linear equations has an effect on the student's performance as shown in this research. This is in agreement with Olubodun (2016) who opined jigsaw cooperative learning strategy improved the performance of mathematics students, and Oluwatosin and Bello (2015) that jigsaw cooperative learning strategy is an effective tool for improving the performance of student in Physics.

The results further confirm Basyah & Muslem (2017) assertion that jigsaw cooperative learning strategy shows significant positive changes in learning outcomes and student learning styles compared to conventional learning models. Yemi, Azid

and bin Md Ali (2018) also found that students' achievement of the experimental group which studied using the jigsaw cooperative learning strategy are better than the students who learn by lecture method because it can help students in solving problems. Besides being able to improve learning outcomes, several studies related to the jigsaw cooperative learning strategy as done by Yasri (2017), that the application of the jigsaw type cooperative learning strategy can increase students' activity during the learning process, which is characterized by an increase in the activeness of students in asking and answering at 2 Walenrang Vocational High School.

In a nutshell, the findings from this study show that students taught with jigsaw strategy performed better than those taught with the traditional method. Also, the students taught with jigsaw strategy were able to solve questions on word problems involving linear equations. Finally, having observed the great prospects that jigsaw strategy has on these learners, it would be appropriate to use it more often in teaching and learning of word problems involving linear equations in one variable in Ghanaian classrooms.

The research question two explored the views of students about the use of jigsaw strategy in teaching and learning word problems. Data to answer research question 2 was gathered through a semi–structured interview. The overall impact in using jigsaw strategy on students understanding and solving of word problems involving linear equations was positive. The findings revealed that students did not know that they could learn better from their classmates until the intervention stage. The intervention made students develop more positive attitude towards word problems involving linear equations because they were more excited as they could easily answer thought provoking questions and reach conclusion. The findings from the study show that

using jigsaw strategy in teaching helped students to have an easy understanding of mathematics, it helped facilitate easy learning and understanding of word problem and made learning word problems more interesting and exciting.

These findings are consistent with Surfaifel et al., (2021) who concluded in their study that students' perceptions collected in their study towards cooperative learning with the jigsaw technique showed that the greatest of the students chose to agree and firmly approved with the questions raised where they agreed that collaborative learning with the jigsaw technique made students more actively involved in the class. Also, it made students more comfortable to understand the material which has been taught. From the findings, it can be concluded that collaborative studying with the jigsaw technique assists the learners in understanding the lesson.

The findings of this research were similar to Wichadee (2005) and Hidayati et al., (2018) who concluded that students have positive perceptions about cooperative learning, especially for jigsaw activities. Because they think that jigsaw can improve their communication skills, and teamwork.

These findings corroborate a study by Ahmed, Melesse and Wondimuneh (2020) who also found out that cooperative problem-solving learning experiences contributed to social skills growth, critical thinking skills, where positive interpersonal and social relationships became noticeable and more achievement. Findings further showed that students had a higher confidence level in cooperative problem-solving as compared to working individually.

The hypothesis set for the third objective, that is;

H_0: There is no significant difference between the performance of students taught by jigsaw strategy and those taught using the traditional approach. In the findings of this study, H_0 was rejected. These findings support earlier studies that concluded that the use of the jigsaw strategy improved achievement scores compared to the conventional teaching methods (Hanze & Berger, 2007).

The findings of Marhamah and Mulyadi (2013) results showed that students in the experimental group, who perceived their instruction as more cooperative and more student-centred, had significantly greater improvement on achievement measures than did the students in the control group and this corroborates with the findings of this current study.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter consists of the summary of the study, the key findings, conclusion and recommendations based on the findings.

5.1 Summary of the Study

The study used jigsaw strategy to address St. Mary's Boys' Senior High School, Apowa students' difficulties in solving word problems involving linear equations. The research approach used in this study was mixed method adopting a quasi-experimental design especially non-equivalent quasi-experimental design was used in the study to investigate the effect of two teaching strategies (jigsaw strategy and traditional method) on the performance of the students. The target population was all SHS form 1 in St. Mary's Boys' Senior High School.

Purposive sampling technique procedure was used to select the two intact class for the study in which one with class size 50 constituted the experimental group and the other with class size 46 constituting the control group. Five (5) students were also randomly selected from the experimental group for the interview. The data collection was done by the researcher.

Pre-test and post-test as well as interview guide were used to collect data before and after the treatment period which took three weeks. Descriptive statistics such as percentages, frequency, tables, means, and standard deviations were used to describe the general performance of students and paired sample t-test was used to compare the mean mathematics achievement scores between the control and experimental groups.

The research question one intended to identify the difficulties SHS students encounter in translating word problems into linear equations. After a critical analysis of the pre-test, the researcher came across four major categories of difficulties namely:

- students attempting but demonstrating misunderstanding of the problem
- students attempting and unable to translate problem into equation(s)
- students attempting but fail to solving the equation to reach the solution
- students attempting to solve the equation but failing to use the right methods or making errors.

Research question two was answered using the responses of students from the interviews. The responses from students suggest that, when mathematics is taught in a more practical way, it becomes easier to understand every concept there by helping them to overcome their difficulties in solving word problems involving linear equations.

The researcher took the participant through an intervention phase to aid students in solving word problems involving linear equations in order to minimise the students' difficulties in an experiment in which one group was treated with the jigsaw learning strategy and the other with the traditional approach. The outcome from the intervention portrayed that there was a statistically significant difference between the mathematics achievement mean scores of the experimental group and that of the control group [$t(49) = 9.497$, $p < 0.05$].

5.2 Conclusion

The success of this study using the jigsaw cooperative learning strategy revealed that classroom teachers should include constructivism within the learning environment. The results of the test show that when students are given the opportunity to construct

their own knowledge under the guidance of a teacher, they will be able to learn mathematics with little difficulty. Since students learn better when they do things by themselves, search for information and learn on their own under the guidance of a teacher, the jigsaw strategy should be part of the classroom teachers' methods of imparting knowledge to the students. True school transformation requires an authentic commitment to developing an investigative environment for both students and teachers. This authentic commitment involves creating a democratic environment, providing learning activities that are interactive and student-centred and the teacher facilitating the learning process where students would be encouraged to be responsible and autonomous.

This study illustrates that when a teacher is committed to improving students' success in learning mathematics, he or she can transform the learning climate through the use of jigsaw which will go a long way to benefit a majority of the students academically. It should be noted that although this study was a success, it may not be a template for every teaching/learning environment. Students with special needs might need different strategies to keep them on track.

5.3 Recommendations

For the effective implementation of the jigsaw strategy, the following recommendations were outlined based on the results of the study;

- Ghana Education Service should organize training workshops and seminars for mathematics teachers to ensure that teachers consider the background of learners since learning should be established based upon the prior knowledge and experience of the students

- Teachers should be encouraged by education stakeholders like the Ghana Education Service, Mathematical Association of Ghana to use jigsaw strategy in teaching mathematics. However, it should be used to the topics where it is applicable.
- Teachers should facilitate the exchange of student ideas as shown in jigsaw strategy since learning is a social process and students should not learn in isolation.

5.4 Suggestions for Further Research

The following suggestions are made to be considered for further research:

- The study should be replicated to include private SHS in Ghana and
- Similar study should be conducted in other regions in Ghana and the results compared with the findings of this research.

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APPENDIX A

INTRODUCTORY LETTER

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF MATHEMATICS EDUCATION

RECEIVED
Date 10/01/23

December 20, 2022

Dear Sir/Madam,

LETTER OF INTRODUCTION: PHILIP SAAH (202151100)

I write to introduce to you the bearer of this letter, Mr. Philip Saah, a postgraduate student in the University of Education, Winneba. He is reading for a Master of Philosophy degree in Mathematics Education and as part of the requirements of the programme, he is undertaking a research titled – ***Using Jigsaw cooperative learning strategy as a tool to address Senior High School students' difficulties in solving word problems involving linear equations.***

He needs to gather information to be analysed for the said research and he has chosen to do so in your institution. I would be grateful if he is given the needed assistance to carry out this exercise.

Thank you.

Yours faithfully,

DEPARTMENT OF MATHEMATICS EDUCATION
UNIVERSITY OF EDUCATION
WINNEBA

Dr. Ali Mohammed
Graduate Coordinator

APPENDIX B

LETTER OF CONSENT

ST. MARY'S BOYS' SENIOR HIGH SCHOOL

HEADMASTER:
Augustine Ackah (MA, BEd)

In case of reply, the number and the date of this letter should be quoted

Bankers:
Bank of Ghana, Takoradi
Ghana Commercial Bank
Takoradi Main

Our Ref. SMBSHS/SP/TSP/PF/20

Your Ref.....

Mobile: 0244920143
Phone: 031-2091110

P. O. Box 279
Takoradi, Ghana
West Africa

16TH JANUARY, 23

.....20.....

TO WHOM IT MAY CONCERN

LETTER OF CONSENT
MR. PHILIP SAAH

We refer to your letter dated December 20, 2022 regarding a research undertaking by the student named above. You are informed that management has approved for you to carry out the research in our school

The school community shall accord you the necessary co-operation and support needed to enable you carry out the exercise.

ST. MARY'S BOYS' SNR. HIGH SCH.-APOWA

JOHN DADZIE THOMPSON
ASSISTANT HEADMASTER (ACADEMICS)

FOR: HEADMASTER

APPENDIX C

PRE-TEST

Dear Respondent, I am a postgraduate student of the University of Education, Winneba conducting a research on "Using jigsaw strategy as a tool to address senior high school students' difficulties in solving word problems involving linear equations".

Below is a Pre-test. Please respond to the items according to the instructions.

Thank you.

Instructions

Attempt all questions. Each respondent is required to fill his personal data in Section A.

Time allowed: 60 minutes

Section A : Biodata of student

1. School :……

2. Class :……

3. Age :……

4. Sex :……. ……..

Section B

Part 1

Write down the equations represented by the statements in this part

1. Twice a number is decreased by two the result is twenty-five.

2. Twelve minus a number is equal to four times that number.

3. The quotient of a number and eight is six.

4. The sum of thrice a number and four is forty-two.

5. Twice a number is five times the sum of the number and seven.

Part 2

Write down the statements represented by the following equations

6. $m + 10 = 4m$

7. $40 + 3j = j - 7$

8. $a + b = 14$ ----------Equation 1

   $ab = 33$ ---------- Equation 2

9. $x + (x + 2) + (x + 4) = 75$

10. $0.10(y + 7) = 5$

Part 3

Read carefully and solve each of the following word problems involving linear equations. Show details of all calculations.

11. The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?

12. The sum of four consecutive odd numbers is thirty-two. What are the numbers?

13. Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?

14. Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?

15. A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.

GOOD LUCK!!!

APPENDIX D

PRE-TEST MARKING SCHEME

QUESTION	DETAILS	MARKS
	SECTION B **PART 1** Let m be the unknown variable	2 Marks each
1	$2m - 2 = 25$	
2	$12 - m = 4m$	
3	$\frac{m}{8} = 6$	
4	$3m + 4 = 42$	
5	$2m = 5(m + 7)$	
PART 2		
6	Ten added to a number is four times the number	2 Marks each
7	If thrice a number is added to forty, the result is the number decreased by seven	
8	The sum of two numbers is fourteen and their product is thirty-three	
9	Three consecutive odd integers add up to seventy-five	
10	10% of the sum of a number and seven is five	
PART 3		
11	Let the numbers be x and y $xy = 12$----------Eqn 1 $x = y - 1$----------Eqn 2 Put $x = y - 1$ into Eqn 2 $(y - 1)(y) = 12$ $y^2 - y - 12 = 0$ $(y + 3)(y - 4) = 0$ $y = -3$ or 4 Put $y = 4$ into Eqn 2 $x = 4 - 1$ $x = 3$	M1 for any M1 M1 M1 A1 A1
12	Let the numbers be x, $(x + 2)$, $(x + 4)$ and $(x + 6)$ Sum: $x + (x + 2) + (x + 4) + (x + 6) = 32$ $4x + 12 = 32$ $4x = 20$ $x = 5$ The numbers are 5, 7, 9 and 11	B1 M1 M1 M1 A1 A1

QUESTION	DETAILS	MARKS
13	Let son's age = x and Mum's age = $5x + 6$ Sum of their ages: $x + (5x + 6) = 48$ $6x + 6 = 48$ $6x = 42$ $x = 7$ Hence the son is 7 years old	B1 for any M1A1 M1 M1 A1
14	Let adults x and children = y $x + y = 150$----------Eqn 1 $500x + 200y = 60{,}000$ $2x + y = 240$----------Eqn 2 Solving Equations 1 and 2 simultaneously $x = 90$ $y = 60$ Hence 90 adults and 60 children were on board the plane	M1 M1 M1A1 M1A1
15	Let x = first piece $3x$ = second piece $x + 40$ = third piece Sum: $x + 3x + (x + 40) = 180$ $5x + 40 = 180$ $5x = 140$ $x = 28$ Hence the first piece is 28 m. second piece is 84 m and the third piece is 68 m.	M1 M1 M1 M1 A1 A1

APPENDIX E

POST TEST

Dear Respondent, I am a postgraduate student of the University of Education, Winneba conducting a research on "Using jigsaw strategy as a tool to address senior high school students' difficulties in solving word problems involving linear equations".

Below is a Post Test. Please respond to the items according to the instructions.

Thank you.

Instructions

Attempt all questions. Each respondent is required to fill his personal data in Section A

Time allowed: 60 minutes

Section A : Biodata of student

1. School :……

2. Class :……..……

3. Age :……

4. Sex :……. ……..

Section B

Part 1

Write down the equations represented by the statements in this part

1. Twice a number is increased by two the result is thirty.

2. Five times a number is subtracted from seven and the result is eighteen.

3. The product of a number and five is twenty-five

4. Half a number added to eight gives thrice the number subtracted from 5.

5. The square root of twelve minus a number is equal to four times that number.

Part 2

Write down the statements represented by the following equations

6. $2d = 5(d + 7)$

7. $40 - 3j = j + 7$

8. $a - b = 21$ ----------Equation 1

   $ab = 33$ ---------- Equation 2

9. $x + (x + 2) + (x + 4) = 75$

10. $0.10(y + 7) = 5$

Part 3

Read carefully and solve each of the following word problems involving linear equations. Show details of all calculations.

11. The product of two integers is twelve, and one of the integers is one less than the other. What are the two integers?

12. The sum of four consecutive odd numbers is thirty-two. What are the numbers?

13. Nana Yaa is six years older than five times her son's age. The sum of their ages is forty-eight. How old is the son?

14. Tickets for a flight from Takoradi to Tamale are GH¢ 500.00 and GH¢ 250.00 for adults and children respectively. A plane took off with a full load of 150 passengers, and the total ticket sales were GH¢ 60,000.00. How many adults and children were on board the plane?

15. A hundred and eighty-meter cable must be cut into three pieces. The second piece must be three times as long as the first. The third piece must be forty meters longer than the first. Find the length of each piece.

GOOD LUCK!!!

APPENDIX F

POST TEST MARKING SCHEME

QUESTION	DETAILS	MARKS
	SECTION B **PART 1** Let m be the unknown variable	2 Marks each
1	$2m + 2 = 30$	
2	$7 - 5m = 18$	
3	$5m = 25$	
4	$8 + \frac{1}{2}m = 5 - 3m$	
5	$\sqrt{12 - m} = 4m$	
PART 2		
6	Twice a number is five times the sum of the number and seven.	2 Marks each
7	Thrice a number subtracted from forty is thrice the number increased by seven	
8	The difference of two numbers is twenty-one and their product is thirty-three	
9	Three consecutive odd integers add up to seventy-five	
10	10% of the sum of a number and seven is five	
PART 3		
11	Let the numbers be x and y $xy = 12$----------Eqn 1 $x = y - 1$----------Eqn 2 Put $x = y - 1$ into Eqn 2 $(y - 1)(y) = 12$ $y^2 - y - 12 = 0$ $(y + 3)(y - 4) = 0$ $y = -3$ or 4 Put $y = 4$ into Eqn 2 $x = 4 - 1$ $x = 3$	M1 for any M1 M1 M1 A1 A1
12	Let the numbers be x, $(x + 2)$, $(x + 4)$ and $(x + 6)$ Sum: $x + (x + 2) + (x + 4) + (x + 6) = 32$ $4x + 12 = 32$ $4x = 20$ $x = 5$ The numbers are 5, 7, 9 and 11	B1 M1 M1 M1 A1 A1

QUESTION	DETAILS	MARKS
13	Let son's age = x and Mum's age = $5x + 6$ Sum of their ages: $x + (5x + 6) = 48$ $6x + 6 = 48$ $6x = 42$ $x = 7$ Hence the son is 7 years old	B1 for any M1A1 M1 M1 A1
14	Let adults x and children = y $x + y = 150$----------Eqn 1 $500x + 200y = 60{,}000$ $2x + y = 240$----------Eqn 2 Solving Equations 1 and 2 simultaneously $x = 90$ $y = 60$ Hence 90 adults and 60 children were on board the plane	M1 M1 M1A1 M1A1
15	Let x = first piece $3x$ = second piece $x + 40$ = third piece Sum: $x + 3x + (x + 40) = 180$ $5x + 40 = 180$ $5x = 140$ $x = 28$ Hence the first piece is 28 m. second piece is 84 m and the third piece is 68 m.	M1 M1 M1 M1 A1 A1

APPENDIX G

SEMI-STRUCTURED INTERVIEW QUESTIONS FOR LEARNERS

Interview guide: Using jigsaw strategy as a tool to address senior high school students' difficulties in solving word problems involving linear equations

The following are interview questions that learners will be asked

1. How do you prefer to learn, alone or in a group?
2. Why do you prefer to learn alone or in group?
3. What aspects of your learning of the word problem went well and supported your understanding? Please explain.
4. What aspects did you find difficult in the lesson?
5. Does the use of jigsaw strategy make learning more interesting? How?
6. Do you think you can perform much better in mathematics if your teachers use jigsaw strategy? Please explain.
7. Would you like most of your mathematics lessons to be taught using jigsaw strategy?
8. Have you ever had a really bad experience with mathematics? If so, what happened?
9. What could teachers do to help students in learning mathematics especially word problem in linear equation?
10. When working a word problem, do you think you know the meaning of most of the vocabulary words in each problem before now? Please give some examples.
11. Why is it important to know the meanings of vocabulary words you see in mathematics?
12. Did you enjoy working word problems before this school year? If no, why do you think this was the case?

13. Has your attitude, perception, or thinking about word problems changed during this semester? If yes, why do you think so?
14. What advice would you like to give to mathematics teachers about the way they teach mathematics, especially word problems?
15. What advice would you like to give to students about the way they learn mathematics, especially word problems?

THANK YOU!!!

APPENDIX H

TRAINING MANUAL ON JIGSAW STRATEGY

Purpose of this manual

The purpose of this manual is to help teachers of mathematics used in this study to plan and implement the jigsaw strategy in the topic word problems involving linear equations to first year students. The jigsaw strategy improves learners' participation in the lesson as it makes learning more interesting to students and can be used to cover a large amount of material quickly.

Aim of the manual

The aim of this manual is to minimize variability among teachers when they teach the topic word problems involving linear equations using jigsaw cooperative learning strategy. Jigsaw strategy is a cooperative learning strategy whereby learners form groups and are given tasks in their groups. Each learner is given a task in the initial groups and those with the same task then form the expert groups where they discuss their tasks. They then go back to the initial groups as experts to represent their findings to the others.

Instructional objectives

Instructional objectives are the end results in a lesson stated in the terms of changes of learner's behaviour. Behaviour here may include; mental (cognitive), emotional (effective) and physical (psychomotor) reactions. Instructional objectives should be stated in terms of learning outcomes because products of learning are of more concerned compared to the process of learning.

Reasons for having instructional objectives

- They provide directions to the teaching process.

- Set the stage for evaluation of the student's learning.

The instructional objectives are classified into the following domains;

Cognitive domain

Objectives in cognitive domain relate to the intellectual abilities and skills. The objectives in this domain can be grouped into six major classes:

- Knowledge - the objectives measures recall with the use of the words List, State, etc
- Comprehension - the objectives measures understanding with the use of the words Classify, Convert, Describe, Explain, etc
- Application - the objectives measures application to other situations with the use of the words Apply, Using, Compute, etc
- Analysis - the objectives uses the words Analyses, differentiate, compare, and contrast.
- Synthesis- the objectives uses the words such as Compose, arrange.
- Evaluation- the objectives uses the words Assess, evaluate, criticize, appraise.

Affective domain

An objective in affective domain relates to attitudes, interests, believes and values. Objectives in this area are beginning to appear more frequently in the curriculum because they relate to issues and topics that are meaningful to young people such as drugs, HIV/AIDS, Pollution, COVID. etc. Five major classes of effective domain are:

- Receiving - the objective uses the words such as choose, listen.
- Responding - the objective uses the words such as Discuss, Report.
- Valuing - the objective uses the words such as Accept, Argue about it, Complete.

- Organization - the objective uses the words such as Organize, Relate, and Modify.
- Characterization by value - the objective uses the words such as Propose, Oppose, and Verify.

Psychomotor domain

Objectives in psychomotor reflects motor skills and hard eye conditions. They have a place in teaching of science especially in the laboratory. The terms used in writing objective in this area include: Build, Construct, Calibrate, Display, Measure etc. Objectives in this domain are grouped into six classes;

- Reflex Action.
- Perception abilities-interprets various stimulus.
- Physical abilities- physical strength and stamina required for sustained effort.
- Skilled movements- refers to efficiency and skills in performing complex tasks e.g. swimming, driving.
- Non - discursive communication- communication without producing sound (gesture, facial expression).
- Basic fundamental movement- these are walking, gripping, finger manipulation.

APPENDIX I

LESSON PLAN – WEEK ONE

NAME OF SCHOOL: ST. MARY'S BOYS' SENIOR HIGH SCHOOL, APOWA

SUBJECT: CORE MATHEMATICS

REFERENCES:

Aki-Ola series (Millenium Edition 2). Core Mathematics for S.H.S Page 133 - 151

Akrong Series (New International Edition 7). Core Mathematics for S.H.S Page 58 - 79

DURATION: 60 MINUTES

TOPIC/ SUB TOPIC: ALGEBRAIC EXPRESSIONS

SPECIFIC OBJECTIVES: By the end of the lesson, the student will be able to:

- Write mathematical expressions for verbal expressions.
- Write verbal expressions for mathematical expressions.

TEACHING AND LEARNING ACTIVITIES:

Teaching Approach: Jigsaw strategy

- The teacher divides the students into 5 person's jigsaw groups which should be diverse of ability and explains to them the objectives of the lesson. These are the initial groups called the "home" groups.
- The teacher appoints one person from each group as a leader.
- The teacher divides the lesson into five tasks and writes them on the markerboard.
  (a) The quotient of eleven and a number t
  (b) Eight more than twice a number
  (c) $3x - 2$
  (d) $\frac{2}{y} + 5$
  (e) Two times a number subtracted from 5
- The teacher gives each student in each group a number between 1 to 5. Those

with number 1 takes the first task, those in number two takes the second task and so on.

- The students are given time to write down their answers and become familiar with it.
- Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task.
- The teacher brings the students back to their jigsaw groups.
- The teacher asks each student to present his or her task to the group
- The teacher floats from group to group observing the process.
- The teacher gives an assignment on what has been learnt to be marked by the teacher.

CORE POINTS

- Word problems are to be read carefully two or three times to help identify the number of unknowns in the question
- It is important to then represent the number of unknowns in the question by starting from the least.
- Write the expression that model the problem given.
- Carefully check if indeed the model represents the problem given.

CLOSURE

Review the concept of algebraic expressions

EVALUATION

Open-ended Assessment: I will challenge students to write an algebraic expression that they think will be very hard to change into a verbal expression. Then have students exchange expressions and translate into verbal expressions.

LESSON PLAN – WEEK TWO

NAME OF SCHOOL: ST. MARY'S BOYS' SENIOR HIGH SCHOOL, APOWA

SUBJECT: CORE MATHEMATICS

REFERENCES:

Aki-Ola Series (Millenium Edition). Core Mathematics for S.H.S Page 198 - 209

Akrong Series (New International Edition 7). Core Mathematics for S.H.S Page 104 -121

DURATION: 60 MINUTES

TOPIC/ SUB TOPIC: LINEAR EQUATIONS

SPECIFIC OBJECTIVES: By the end of the lesson, the student will be able to:

- Construct a formula (or algebraic expression) for a given mathematical task.
- Find solution sets for linear equations in one variable.

TEACHING AND LEARNING ACTIVITIES:

Teaching Approach: Jigsaw strategy

- The teacher divides the students into 5 person's jigsaw groups which should be diverse of ability and explains to them the objectives of the lesson. These are the initial groups called the "home" groups.
- The teacher appoints one person from each group as a leader.
- The teacher divides the lesson into five tasks and writes them on the markerboard.

(a) Solve $5x + 2 = 2x + 17$

(b) Find the truth set of $3(2x - 1) + 4 = 5(x + 4) + 2$

(c) Solve $\frac{2}{3}(3y - 1) - (y + 2) = \frac{1}{3}$

(d) Given $\frac{4}{3+x} = \frac{5}{2-x}$, find x

(e) Solve $\frac{2x-1}{3} - \frac{x-2}{4} = 1$

- The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on.
- The students are given time to write down their answers and become familiar with it.
- Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task.
- The teacher brings the students back to their jigsaw groups.
- The teacher asks each student to present his or her task to the group
- The teacher floats from group to group observing the process.

  The teacher gives an assignment on what has been learnt to be marked by the teacher.
- The teacher gives an assignment on what has been learnt to be marked by the teacher.

CORE POINTS

General steps for solving linear equations:

- Check if there are fractions. If there are fractions, multiply both sides of the equation by the LCM of the denominators to clear the fractions.
- Check if there are brackets. If there are brackets, expand to remove the brackets.
- Group like terms on one side.
- Simplify both sides of the equation and solve for the variable.

CLOSURE

Review the concept of linear equations.

LESSON PLAN – WEEK THREE

NAME OF SCHOOL: ST. MARY'S BOYS' SENIOR HIGH SCHOOL, APOWA

SUBJECT: CORE MATHEMATICS

REFERENCES:

Aki-Ola Series (Millenium Edition). Core Mathematics for S.H.S Page 198 - 209

Akrong Series (New International Edition 7). Core Mathematics for S.H.S Page 104 - 121

DURATION: 60 MINUTES

TOPIC/ SUB TOPIC: WORD PROBLEMS INVOLVING LINEAR EQUATIONS

SPECIFIC OBJECTIVES: By the end of the lesson, the student will be able to:

- Translate word problems into linear equations and vice versa
- Solve word problems involving linear equations

TEACHING AND LEARNING ACTIVITIES:

Teaching Approach: Jigsaw strategy

- The teacher divides the students into 5 person's jigsaw groups which should be diverse of ability and explains to them the objectives of the lesson. These are the initial groups called the "home" groups.
- The teacher appoints one person from each group as a leader.
- The teacher divides the lesson into five tasks and writes them on the markerboard.

(a) Twice a number is subtracted by 6. The result is then divided by 8 which is then added to 5 to produce a final result of 12. Find the number.

(b) A number is chosen and is subtracted by 8. The result is then divided by 3. If the final answer is 12, find the number.

(c) When a certain number is subtracted from 10 and the result is multiplied by 2, the result is 4. Find the number.

(d) Peter is 7 years older than his wife, Wendy. The sum of their ages is 63. Find Peter's age.

(e) The sum of the ages of two brothers (Kofi and Yaw) is 36. If Kofi is 10 years older than his brother, how old is Kofi?

- The teacher gives each student in each group a number between 1 to 5. Those with number 1 takes the first task, those in number two takes the second task and so on.
- The students are given time to write down their answers and become familiar with it.
- Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their task.
- The teacher brings the students back to their jigsaw groups.
- The teacher asks each student to present his or her task to the group
- The teacher floats from group to group observing the process.

The teacher gives an assignment on what has been learnt to be marked by the teacher.

CORE POINTS

Algebra is often used to solve problems given in words and sentences. To solve such problems:

- Read the information given carefully
- Choose a letter to represent one unknown quantity you have to find.
- Use the information given to find two equal expressions. Write these expressions as an equation
- Solve the equation you have made and use the solution to answer the question.
- Use the original information given to check your solution.

CLOSURE

Review the concept of linear equations.

APPENDIX J

THE GRAPHICAL REPRESENTATION OF THE DIFFICULTIES OF STUDENTS IN SOLVING WORD PROBLEMS

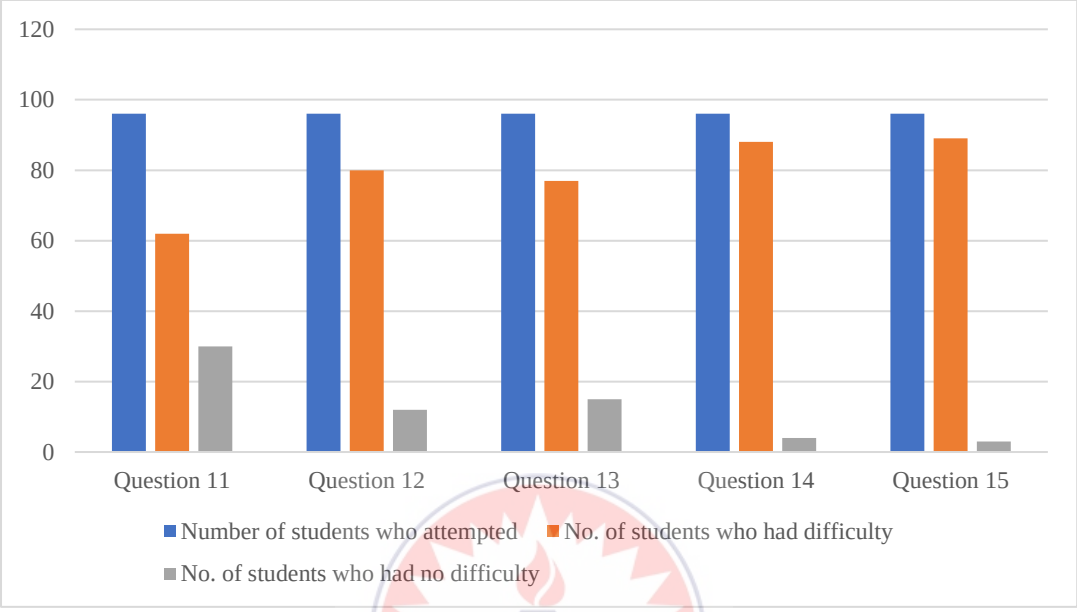

Figure 5.1: Frequency distribution of students attempting but demonstrating misunderstanding of the problem

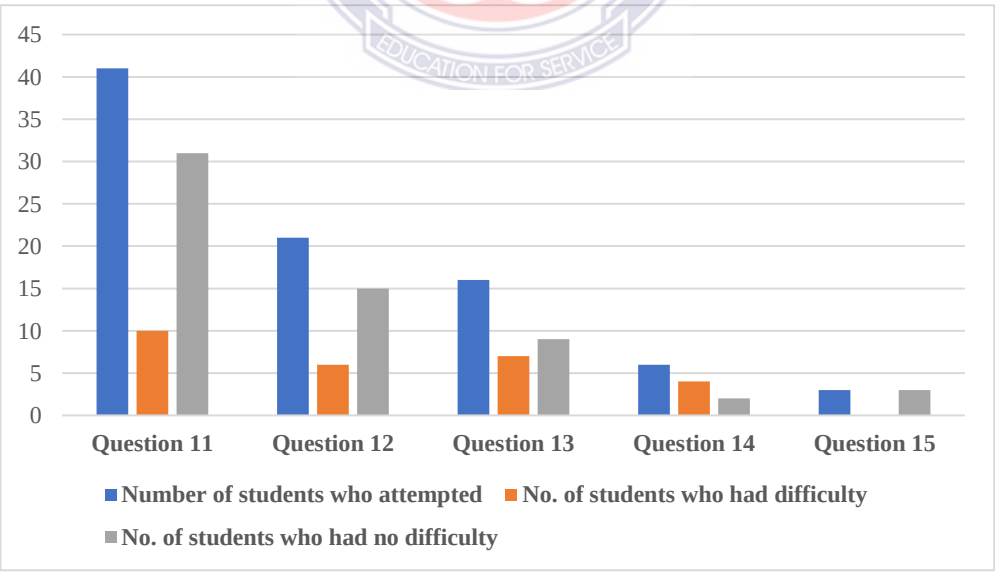

Figure 5.2: Frequency Distribution of students attempting and unable to translate problems

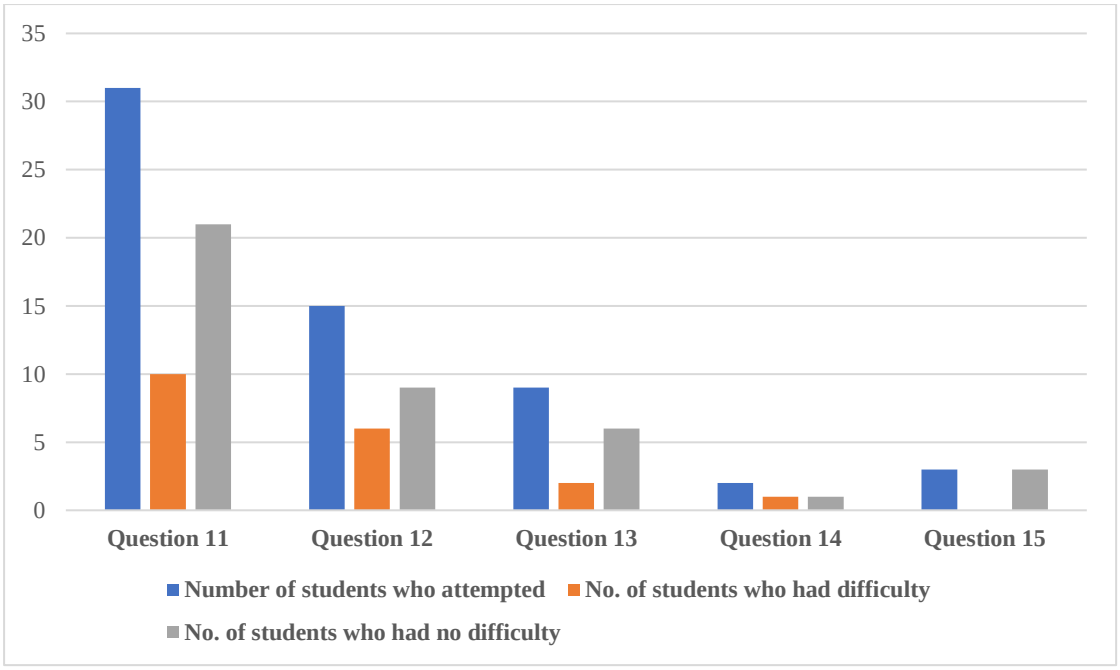

Figure 5.3: Frequency Distribution of students attempting but failing to solve the equation to reach the solution

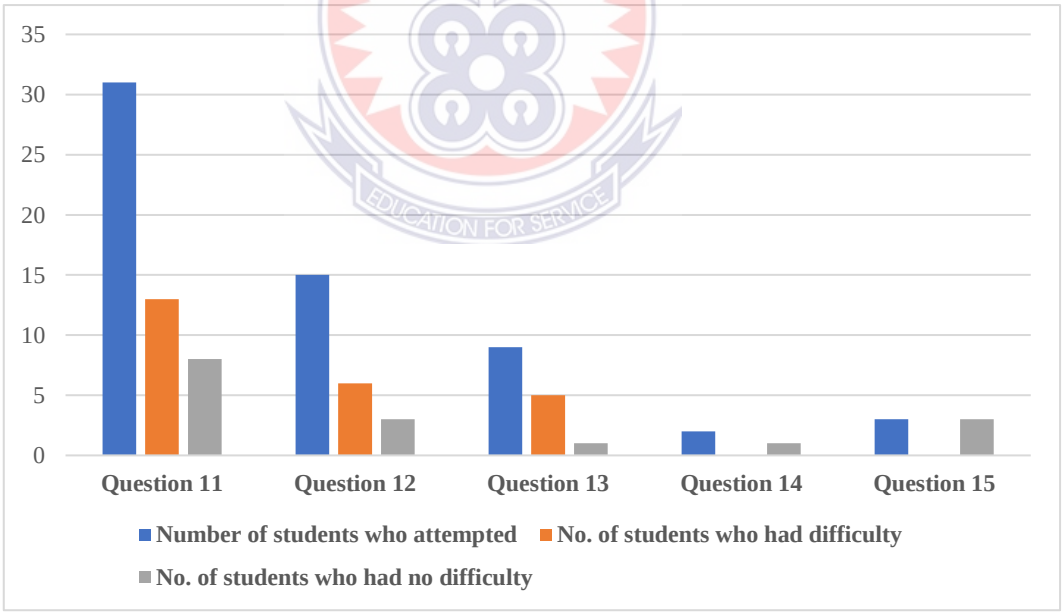

Figure 5.4: Frequency distribution of students attempting but failing to use the right methods to reach the solution for the equation.

APPENDIX K

Intervention schedule of activities in the classroom

Week	Activity	Remarks
Week 1	Pre-test assessment/ Round table discussion	All students participated Students discussed their difficulties with the researcher
Week 2	Introduction to algebraic expressions	Students participated in the lesson
Week 3	Introduction to linear equations	Students participated fully
Week 4	Introduction to word problems	Successfully done
Week 5	Practical teaching using jigsaw strategy	Every student participated
Week 6	Post test administration	All students participated

APPENDIX L

CALCULATION OF COHEN'S CORRELATION COEFFICIENT FOR PRE-TEST AND POST TEST SCORES FOR EXPERIMENTAL GROUP

$$d = \frac{M_1 - M_2}{\sqrt{\frac{{S_1}^2 + {S_2}^2}{2}}} \quad \Rightarrow \quad d = \frac{22.98 - 13.94}{\sqrt{\frac{(3.212)^2 + (3.067)^2}{2}}} \quad \Rightarrow d = 2.879$$

$$r = \frac{d}{\sqrt{d^2 + 4}} \quad \Rightarrow \quad r = \frac{2.879}{\sqrt{(2.879)^2 + 4}} \quad \Rightarrow \quad r = 0.821$$

CALCULATION OF COHEN'S CORRELATION COEFFICIENT FOR PRE-TEST AND POST TEST SCORES FOR CONTROL GROUP

$$d = \frac{M_1 - M_2}{\sqrt{\frac{{S_1}^2 + {S_2}^2}{2}}} \quad \Rightarrow \quad d = \frac{14.24 - 12.02}{\sqrt{\frac{(6.352)^2 + (2.499)^2}{2}}} \quad \Rightarrow d = 0.460$$

$$r = \frac{d}{\sqrt{d^2 + 4}} \quad \Rightarrow \quad r = \frac{0.460}{\sqrt{(0.460)^2 + 4}} \quad \Rightarrow r = 0.224$$

APPENDIX M

Basic terminologies used in algebraic expressions

Operation	Terminologies
Addition	Add, sum, total, plus, In all, both, together, how many in all, increase by, older than, more than, another, raised by, Join etc.
Subtraction	Subtract, difference, take away, less than, remain, decreased by, how much less, fewer, reduce, smaller than, left over.
Multiplication	Times, product, doubled, multiplied by, twice as, by, of, factor of.
Division	Quotient, divided by, half of, split, share, parts, and ratio, separated.

APPENDIX N

Sample word problems solving techniques

Example	Situational Type	Keywords	Operational symbol and word
Kate is seven years older than Alice. In three years, Amu will be twice as old as Alice. Find their present age?	Word problem involving age	Older than and Twice	Addition (+) and Multiplication (×)
Berty, Maame Yaa and Adwoa shared GH¢ 720.00. Ama received twice as much as Adwoa and Kwesi received three times as much as Ama. How much did each receive?	Word problem involving money	Twice, times	Both Multiplication (×)
The length of a rectangle is 10 m more than its breadth. If the perimeter of rectangle is 80 m, find the dimensions of the rectangle.	Word problem involving geometry	More than	Addition (+)
A number is 8 more than another number. The sum of the numbers is 23. What are the numbers?	Consecutive digits word problem	Sum	Addition (+)