UNIVERSITY OF EDUCATION, WINNEBBA

INVESTIGATING THE EFFECT OF PROBLEM SOLVING APPROACH ON SENIOR HIGH SCHOOL STUDENTS' PERFORMANCES IN ALGEBRAIC LINEAR EQUATION WORD PROBLEMS

AMADU BRAIMAH

MASTER OF PHILOSOPHY

JULY, 2020

UNIVERSITY OF EDUCATION, WINNEBBA

INVESTIGATING THE EFFECT OF PROBLEM SOLVING APPROACH ON SENIOR HIGH SCHOOL STUDENTS' PERFORMANCES IN ALGEBRAIC LINEAR EQUATION WORD PROBLEMS

AMADU BRAIMAH
(8184000008)

**A Thesis in the Department of Mathematics Education,
Faculty of Science Education, submitted to the School of Graduate Studies in partial fulfilment**

**of the requirements for the award of the degree of
Master of Philosophy
(Mathematics Education)
in the University of Education, Winneba**

JULY, 2020

DECLARATION

STUDENT'S DECLARATION

I AMADU BRAIMAH, 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.

SUPERVISOR'S NAME DR. JOSEPH I. NYALA

SIGNATURE …………………………………….

DATE ……………………………………………..

ACKNOWLEDGEMENT

First of all, I give thanks to the almighty God whose protection, mercies and guidance has brought me this far.

I am very grateful to my supervisor Dr. Joseph I. Nyala for his advice, support, guidance and direction in the course of the study. Many thanks go to Prof. D. K. Mereku, for his guidance and support in the course of my programme of study. To Dr. Peter Akayuure, I thank you for your support, motivation and encouragement. I am grateful to all the lecturers in the Department of Mathematics Education at University of Education, Winneba for their support and advice that they offered me throughout the entire duration of my programme. Am grateful to everyone who contributed in one way or the other to make this project a reality. Many thanks also go to all my M.Phil Mathematics Education 2018 colleagues for their company, support and love shown me throughout my entire studies.

My proud gratitude also goes to the mathematics teachers at Asuom Senior High School and Kade Senior High Technical School for their support during the fieldwork. I am grateful to all the students who participated in this study. God richly bless you.

Finally, I am grateful to my son Anas Amadu and daughter Khadijah Amadu and all my siblings for their encouragement and support given to me

DEDICATION

I dedicate this work to the entire Braimah's family.

TABLE OF CONTENTS

Contents **Pages**

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study was conducted to investigate the effect of problem solving approach of teaching on senior high school students' performances in solving algebraic linear equation word problems. A quasi-experimental non-equivalent pretest-posttest control group research design was employed and adopted a mixed method of data analysis and presentation. The study involved thirty (30) students in the experimental group and twenty-two (22) in the control group in the Kwaebibirem Municipality of Eastern Region of Ghana. The experimental group was exposed to problem-solving teaching strategies, while the control group was taught using a traditional teaching approach. A pre-test was conducted before the treatment and a post-test after the treatment. The pre-test and post-test scores obtained by the students were analysed using the Statistical Package for Social Sciences (SPSS) software. Upon scrutiny of students' pre-test marked scripts, students' difficulties in solving algebraic linear equation word problems were found to be: (1) Lack of understanding of the problem statement; (2) misinterpretation of the problem statement; (3) computational errors, and (4) inability of students to apply the appropriate mathematical knowledge. The analysis of students' pre-test and post-test scores also showed that students in both control and experimental groups performed better in the post-test than the pre-test, however, the experimental group made more improvement in solving algebraic linear equation word problems as compared to students in control group. The study, therefore, recommends that mathematics teachers should employ problem-solving approach of teaching in their lessons in order to enhance students' understanding of mathematics concepts, hence, improving their performance in mathematics.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter presents the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, research hypothesis, significance of the study, delimitations, limitations, and the organizational plan of the study.

1.1 Background of the Study

Mathematics is a compulsory subject for all students at the Senior High School (SHS) level in Ghana. This is necessitated by the fact that knowledge of Mathematics is important for all members of a society to function well. According to Adu, Mereku, Assuah, and Okpoti (2017), a strong background in Mathematics and its applications is essential in many technically oriented work sectors. This is because Mathematics forms the basis of critical, analytical and logical problem solving that is often vital in many fields of work.

At the Senior High School level, Mathematics education is meant to enable all Ghanaian young persons to acquire the mathematical skills, insights, attitudes and values that they will need to be successful in their chosen careers and everyday lives (Ministry of Education [MOE], 2010). The National Council of Teachers of Mathematics (NCTM, 2009) stated that problem solving skills are the main expectations of teaching Mathematics. Similarly, the purpose of Mathematics education is to enable students solve problems in their daily lives. Mathematics is an important subject not only for academic success in school, but also a subject that prepares students for the future irrespective of which career they may choose to be part of (Davies & Hersh, 2012). The rationale for teaching Mathematics therefore is to prepare students for life by equipping them with knowledge, skills, ability to think logically and analytically and develop their ability to solve problems in different fields. Mathematics is recognized as an important subject all over the world because of its relevance to science and technology. It has been described as the bedrock and an essential tool for scientific, economic and technological advancement of any nation (Umameh, 2011; Charles-Ogan & Otikor, 2016). It is therefore clear as indicated by Sherrod, Dwyer and Narayan (2009) that nations in the world with strong focus on the study of Mathematics and Science are leading in their economics and technological advancements. This was supported by Bassey, Joshua and Asim (2011) that mathematics is an important device for the understanding and application of science and technology and serves as a base for national development and the world at large.

In spite of the crucial role Mathematics plays in the life of every individual and the nation in general, students in senior high schools continually register poor results at the West Africa Senior School Certificate Examination (WASSCE). This poor performance is evident in the results in core Mathematics for May/June WASSCE from 2015 to 2018. The percentage of candidates with grades (A1 – C6) in Mathematics increased from 25.29% in 2015 to 32.83% in 2016 and then increased again to 42.73% in 2017. In the subsequent year, this trend did not continue as expected. The performance of the candidates in Mathematics dropped from 42.73% in 2017 to 38.33% in 2018. Also, analysis of the results of Ghanaian students who participated in the Trends in International Mathematics and Science Study (TIMSS) for Junior High School year two (grade 8) in 2007 and 2011 revealed their weakness with an average scores of 309 and 331 respectively in Mathematics which were far lower than the international average mark of 400 (Mullis, Martin, & Foy, 2008; Mullis, Martin, Foy & Arora, 2012).

Most Mathematics classrooms in Ghana are still characterized by Traditional Teaching Approach (TTA) which Masingila, Lester, and Raymond (2011) described as an instructional approach whereby a teacher attempts to impart the knowledge of Mathematics to students who sit quietly, listen to the teacher and later practice what the teacher taught them. Ampadu (2012) contends that most mathematics teachers in Ghana are still considered as the custodians of knowledge in the classrooms by their students and these students have the impression that their success in mathematics depends on their ability to follow their teacher's instructions and approach of solving problems. This approach of teaching does not promote active participation of students in the process of knowledge acquisition, but rather turn them to passive receivers of information. Akyeampong, Lussier, Pryor, and Westbrook (2013) defined traditional teaching approach as a teaching strategy where lessons are delivered by given a set of rules to students to be followed without the students knowing how those concepts came about. In this approach, students are not given the opportunity to participate in the learning process, hence they become passive receivers of knowledge. It has been found in many studies that the traditional teaching approach in classroom has limited effectiveness in the teaching and learning process (Anderson, 2007; Clement, 2013). This teaching approach is perhaps a contributing factor to the poor performance of students in Mathematics.

Mereku (2010) attributed the abysmal performance of students in Mathematics to the non-utilisation of appropriate teaching methods in the traditional Ghanaian classroom. There is therefore the need for an instructional approach that will enhance students' understanding and performance in Mathematics. Good teaching approach may facilitate students' understanding and performances in Mathematics. Rivkin, Hanushek, and Kain, (2005) assert that students who receive high-quality teaching in Mathematics experience greater and more persistent achievement gains than their peers who receive lower-quality teaching in Mathematics.

Problem solving approach (PSA) of teaching is a learner-centered teaching strategy that engages learners actively in the learning process, enhances their understanding of mathematics concepts and develops their problem solving skills. Generally, student-centered instruction is an instructional approach in which learners are given the opportunities to offer their own ideas and to become actively engaged in their learning (Boaler, 2008). According to Tsoho (2011), what generally makes a particular teaching approach student-centered is the ability to involve students actively in the teaching and learning process. Problem solving is described as an individual trying to achieve a goal, when there is no known method to achieve it (Schoenfeld, 2013). This means that difficulty or complexity alone does not make a task a problem. Mereku and Cofie (2008) maintain that problem solving approach to teaching Mathematics goes beyond helping students to solve routine problems (task that can be solved by applying a standard procedure or formula) to non-routine problems (problems that cannot be solved by applying a routine procedure). They added that the ability of students to read and grasp the language of a Mathematics problem is fundamental to success in problem solving. According to Lai, Zhu, Chen and Li (2015), problem solving is a cognitive process directed to achieve a goal when there is no obvious solution path available to the problem solver. Polya (1945) described problem-solving as a practical skill, that can be acquired by imitation and practice in which understanding of mathematical concepts is the goal rather than memorization.

Students learn better when they are given opportunities to participate actively in arranged activities in the teaching and learning process. National Council of Teachers of Mathematics (NCTM) (2014) argued that teaching mathematics should be focused on developing the understanding of students' mathematical concepts and procedural skills through problem-solving, discourse, and reasoning rather than focusing on practicing procedures and memorization skills. In order to develop students' understanding, teachers should engage learners in tasks that encourage high level thinking and promote their problem solving skills (NCTM, 2014). By solving problems, students learn to use their mathematical skills in new ways. Engaging students actively in the teaching and learning process helps develop a deeper understanding of mathematical ideas and concepts. Therefore, exposing students to solving mathematical problems related to real life is crucial in developing their problem-solving skills.

In the mathematics curriculum in Ghana, the teaching through problem solving is emphasised in word problems across topics in Mathematics (MOE, 2010). This emphasis is based on the idea that students will develop important mathematical ideas and competences through a problem solving instruction. According to Hiebert and Wearne (1993), students who actively engage in a problem solving instruction develop, extend, and enrich their understanding. Cai (2010) posits that if students are to become successful problem solvers, problem solving should be an integral part of teaching and learning mathematics and not something to be added after teaching the concepts and skills.

A word problem is described as a verbal descriptions of a problem situation wherein one or more questions are asked, the answer to which is obtained by the application of mathematical operations to numerical data available in the problem statement (Verschaffel, Depaepe, & Van Dooren, 2014; Verschaffel, Greer & De Corte 2000). Word problems mostly involve relating the real world situations to mathematical concepts. In fact, word problems help students to apply their Mathematics knowledge to solve problems in their daily lives. According to (Barwell, 2011), using word problems helps students connect reality to Mathematics. Solving word problems involves interpreting and translating the statements in words into Mathematics notations called expressions or equations before mathematical operations are carried out. This implies that students' reading and comprehension abilities influence how likely they will solve a word problem. Montague (2003) defined mathematical word problem solving as a process involving two stages: 'problem representation' and 'problem execution'. Montague (2003) added that, problem solving is not possible without first representing the problem appropriately. Appropriate problem representation implies that, the problem solver has fully understood the problem and serves to guide the learner towards the solution process. Montague (2003) further stated that, good problem solvers usually used a variety of strategies as they read and represent the problem before they make a plan to carry out the solution process. They first read and use comprehension strategies to translate the text and numerical information in the problem statement into mathematical notations. They paraphrase the problem by putting it into their own words. They identify the important information and may even underline parts of the problem.

According to Verschaffel et al., (2000), solving word problems implies solving real-world problems involving a number of stages. These are:

- understanding and defining the problem situation leading to a situational model.
- constructing a mathematical model of the relevant elements, relations and conditions embedded in the situation.
- working through the model using disciplinary methods to derive some mathematical result(s).
- interpreting the outcome of the computational work in relation to the original problem situation.
- evaluating the model by checking if the interpreted mathematical outcome is appropriate and reasonable for its purpose.
- communicating the obtained solution of the original real-world problem.

Word problems in Mathematics are often presented in English, algebraic letters or both. Therefore understanding English and mathematical language is fundamental for success in problem solving. Proficiency in solving algebraic linear equation word problems can be applied to word problems in other areas of Mathematics.

1.2 Statement of the Problem

A word problem is a verbal description of a problem situation wherein one or more questions are asked in which the answer(s) can be obtained by the application of mathematical symbols and operations to numerical data available in the problem statement (Verschaffel et al., 2000). Word problems, sometimes referred to as story problems are used to give students a glimpse of how Mathematics is applied in the real world. Word problems enable students to become independent analytical thinkers and learners who create new methods to solve the problem. The solution of a word problem depends on the student's ability to translate the numerical data in the text into mathematical notations. In line with Kersaint, Thompson and Petkova (2009), solving word problems involves knowledge about semantic construction and mathematical relations, as well as the knowledge of basic numerical skills and strategies.

Evidence of poor performance in Mathematics in the West African Senior School Certificate Examination (WASSCE) by Senior High School (SHS) candidates in Ghana implies that, the most desired technological, scientific and business application of Mathematics cannot be achieved. Chief Examiner's reports (WAEC, 2014; 2015; 2017) stated that most candidates could not translate word problems into mathematical statements correctly, hence their inability to solve them. Word problems have been reported to be one of the students' difficult areas in Mathematics (Rosales, Santiago, Chamoso, Munez, & Orrantia, 2012).

The difficulties students encounter in the process of solving algebraic word problems may be attributed to ineffective teaching approaches employed by teachers in their lesson delivery. Most teachers use the traditional teaching approach where students watch passively, listen, and later practice what the teacher taught them (Boaler & Staples, 2008). This type of instructional strategy does not promote understanding, analytical thinking and problem solving skills in students. Students develop deeper understanding of mathematical concepts when they are provided with appropriate learning activities. Problem solving approach of teaching allows students to make links of similar problems, to construct their mathematical knowledge and think creatively (Polya, 1945). Problem solving goes beyond the usual thinking and reasoning students adopt while solving exercises. It involves thinking deeply about concepts, their associated representations, appropriate solution procedures, related context and creating problem models (Polya, 1945). This study investigates the effect of a problem solving approach on Asuom Senior High School students' performances in solving algebraic linear equation word problems.

1.3 Purpose of the Study

Developing students' problem solving abilities is important in their success in real and academic life. The poor problem solving abilities exhibited by students during word problem lessons needs to be intervened. This study was therefore an attempt to search for alternative teaching approach aimed at addressing students' difficulties in learning mathematics. The use of effective instructional strategies in the classroom is more crucial now than ever because educational standards were being raised.

The purpose of this study is to investigate the effect of a problem solving approach of teaching on senior high school students' performances in solving algebraic linear equation word problems in the Kwaebibirem municipality in the Eastern Region of Ghana.

1.4 Objectives of the Study

This study sought to determine the comparative effects a problem solving approach of teaching and the traditional teaching approach on senior high school students' performances in solving algebraic linear equation word problems. The objectives of this study were to:

1. identify the difficulties students encounter in solving algebraic linear equation word problems
2. investigate the effect of the traditional teaching approach on students' performances in solving algebraic linear equation word problems

3. investigate the effect of the problem solving approach on students' performance in solving algebraic linear equation word problems
4. examine the difference in performance between students taught algebraic linear equation word problems using traditional approach and problem solving approach
5. examine students' views about the problem solving approach of teaching

1.5 Research Questions

1. What difficulties do students encounter in solving algebraic linear equation word problems?
2. What is the effect of the traditional teaching approach on students' performances in solving algebraic linear equation word problems?
3. What is the effect of the problem solving approach on students' performances in solving algebraic linear equation word problems?
4. What are the views of students about the problem solving approach of teaching?

1.6 Research Hypothesis

Based on the objectives of the study, the null hypothesis was formulated to direct and guide the study and tested at 0.05 level of significance:

H_0: There is no difference in performance between students taught algebraic linear equation word problems using traditional approach and problem solving approach.

1.7 Significance of the Study

This study will introduce a new and reformed instructional strategy that will enhance the students' competencies in solving algebraic linear equation word problems and also deepen their problem solving skills in Mathematics. The outcome of this study will provide information on the effectiveness of a problem solving approach of teaching. This knowledge may change the perception of mathematics teachers towards adoption and implementation of the problem solving approach of teaching.

Furthermore, the results of this study will inform head teachers and educational authorities about the benefits associated with the problem solving approach of teaching. Hence, the need to organise in-service training for their teachers in order to keep them abreast with the modern methods of teaching and learning mathematics.

Also, the findings of this study will serve as a guide to educational authorities and curriculum developers in planning mathematics curriculum for Senior High Schools in Ghana as well as prepare syllabus and textbooks to cater for the current instructional strategies in the mathematics education. The outcome of this study will serve as a reference material for further studies which might be conducted on this topic in the education sector.

Finally, the results of this study will add to the body of literature in research on mathematics education and provide insight into the use of a problem solving approach in teaching mathematics in the Ghanaian classrooms.

1.8 Delimitations

Delimitations are the boundaries, within which researchers intentionally place their study (Calabrese, 2006). This study investigates the effect of a problem solving approach of teaching on Senior High School Students' performances in solving algebraic linear equation word problems. As a result of time and financial constraints, this study was restricted to only First-Year students in the Gold Track of two Senior

High Schools in the Kwaebibirem Municipality of Eastern Region in Ghana. The study focused on form one students because linear equation word problems are taught at this level.

1.9 Limitations

Limitations in research are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on the methodology and conclusion. Students' absenteeism was also a problem, some of the students were not coming to school regularly during the treatment period, but were present to take part in the post-test. Using problem-solving of teaching which students are not familiar with was difficult. However, the researcher did his best to take the students through it. The study period was only three weeks and this places a limitation on the results. A longer time spent during the treatment might have resulted a greater difference between the pre-test and post-test scores, between the control and experimental groups. The conclusion will therefore be limited by these factors and as a result, the findings of this study cannot be generalized to cover all Senior High Schools in Ghana.

1.10 Organisation of the Study

This research is organised into five chapters. Chapter One presents the introduction which includes the overview, background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, research hypothesis, significance of the study, delimitation, limitations and the organizational plan of the study. Chapter Two deals with literature review, that is, the review of relevant literature related to the study. Chapter Three deals with the methodology employed in the study. This covers the research design, population, sample and sampling technique, research instruments, validity, reliability, pilot study, data collection procedure, treatment procedure and data analysis procedure. Chapter Four focuses on data presentation analysis and discussion. Chapter Five provides a summary of findings, recommendations based on the outcome of the study, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter reviews literature related to the study. The literature review covers the theoretical framework of the study, problem solving approach of teaching Mathematics, teachers' role in problem solving instruction, problems, problem solving, solving word problems, students' difficulties in solving word problems, cooperative learning, and the traditional approach of teaching. This chapter also presents the summary of the literature.

2.1 Theoretical Framework

The theoretical framework refers to a group of ideas that guide a research project. Gay, Mills, and Airasian (2009) explained that a theoretical framework identifies the prevailing theory and concepts of a research project.

In this study, a problem solving approach to teaching and problem solving model constructed by Polya (1945) were employed. In Mathematics Education, problem solving involves defining a problem, collecting relevant information related to the solution, carry out the solution, checking and evaluating the solution. Polya (1945) described problem solving as the process used to solve problems that do not have a clear solution path. Polya added that problem solving goes beyond the usual thinking and reasoning students adopt while solving exercises. It involves thinking deeply about concepts, their associated representations, appropriate solution procedures, related context and creating problem models. Polya (1945) asserts that effective word problem solvers go through four stages of problem solving. These are:

- Understanding the problem

- Devising a plan
- Carrying out the plan
- Look back

To begin is *Understanding the problem.* At this first stage, the problem-solvers read through the problem statement for understanding. As they read, they use comprehension strategies to translate the linguistic and numerical information in the problem into mathematical notations. They restate the problem by putting it into their own words. They identify the important information and may underline parts of the problem. Actively reading a problem statement allows students to make sense of it. However, the quality of students' understanding and decoding of the text is fundamental for their success in problem solving (Pape, 2004). Secondly is *Devising a plan.* At this stage, the problem solver generates an appropriate solution plan for solving the problem by breaking it down into a series of steps, often requiring the creation of mathematical notations of the text.

Carry out the plan, at this stage, the arithmetic computations are carried out. This involves solving the problem step-by-step and if the solution is not found, the strategy is changed. *Looking back,* at this last stage of Polya's model, the problem solver checks the previous steps to make sure the answer is correct and reasonable.

2.2 Problem Solving Approach of Teaching Mathematics

According to Schoenfeld (2013), problem solving is a cognitive process directed to achieve a goal when no clear solution path is available to the problem solver. Teaching mathematics through a problem-solving approach provides a learning environment for students to learn on their own, to explore problems and to find new ways to solve the problem. This was supported by Mtitu (2014) that, for effective and efficient teaching, learner-centered approaches that require teachers to actively involve learners in the teaching and learning process must be employed. You (2014), contends that students' participation and active involvement in the teaching and learning process enhance their understanding in the subject. According to D'Ambrosio (2003), teaching Mathematics through a problem-solving approach is based on the notion that students who encounter problematic situations can use their prior knowledge to solve them, and in the process of solving these problems, they construct new knowledge and understanding.

Polya (1945) problem-solving model involves four stages: Understand the problem, Devise a solution plan, Carry out the plan, and Look back. In this teaching approach, students are expected to learn to apply and adapt a variety of problem solving strategies to solve problems. These strategies include drawing diagrams, looking for patterns, listing all possible solution paths, working backward, guessing and checking, and creating a simpler problem. Mereku and Cofie (2008) maintain that problem-solving approach to teaching Mathematics goes beyond helping students to solve routine problems (problems that follow a laid down procedure or formula) to non-routine problems (problems that do not have a clear solution path). Problem-solving strategies help improves students' mathematical understanding and in turn, support students to become more efficient and effective problem solvers.

To make students familiar with problem-solving strategies, teachers should first provide an organised series of steps to be followed by students (North, 1992). This should be in a well-organised plan. Krulik and Rudnick (1987) advised teachers to begin teaching problem solving process with relatively simple tasks to ensure a reasonable degree of success. One important objective of teaching mathematics is to help the students to become familiar with various problem solving strategies and to practice using them" (Krulik et al., 1987, p.2). Students should know how to solve a problem not just finding the solution. Knowing how to solve a problem is ability of students to use problem solving strategies and steps appropriately to new situations.

Characteristics of a problem-solving instruction include:

- interactions between students/students and teacher/students (Van Zoest, Jones & Thornton, 1994)
- mathematical dialogue and consensus between students (Van Zoest et al., 1994)
- teachers providing just enough information to establish the background of the problem, and students clarifying, interpreting, and attempting to construct one or more solution processes (Cobb, Wood & Yackel, 1991)
- teachers guiding, coaching, asking insightful questions and sharing in the process of solving problems (Lester, Masingila, Mau, Lamdin, Dos Santon & Raymond, 1994)
- teachers knowing when it is appropriate to intervene, and when to step back and let the students make their own way (Lester et al., 1994)
- a problem-solving approach can be used to encourage students to make generalizations about rules and concepts, this process is fundamental to Mathematics (Evan & Lappin, 1994).

Teaching mathematics through a problem-solving approach is time-consuming because the discussion of a problem and its alternative solutions usually takes a longer time than the demonstration of a routine classroom activity. Classrooms with the aim of teaching through a problem-solving approach usually used fewer problems and spent more time on each of the problems, compared to those classrooms without a focus on problem solving activities (Hiebert & Wearne, 1993).

Kousar (2010) conducted a study to determine the effect of a problem-solving approach on students' performances in Mathematics at the secondary school level. A sample of 48 students was selected and divided into experimental and control groups based on an assessment he conducted. The experimental group was taught using the guidelines of Polya's (1945) heuristic steps of a problem-solving approach. The control group was taught using the traditional teaching approach. After the treatment, an assessment was carried out to determine the effect of the intervention. A two-tailed t-test was used to analyze the data, which showed that both experimental and control groups were almost equal in Mathematics knowledge before the experiment. However, the experimental group's performance in the assessment was significantly higher than the control group. This suggest that Mathematics concepts and procedural skills learnt through the traditional teaching approach were not well understood by the students. Students were not able to apply the knowledge acquired to solve problems that require application of critical thinking and problem solving skills. Mwelese and Wanjala (2014) researched to examine the effect of problem solving strategy on secondary school students' performances in geometry. Two Mathematics teachers with equal qualifications, teaching experience were selected and trained to teach the two groups. The experimental group was taught using the problem-solving method and the control group was taught using the traditional teaching approach. A post-test was conducted after treatment. The analysis of the results indicate that students who received problem-solving instruction had higher achievement scores than their peers who were taught using the traditional teaching approach.

A study was conducted by Ali, Hukam, Akhter, and Khan (2010) to investigate the effect of a problem-solving method on students' achievements in Mathematics at the elementary level. A pre-test, post-test design was used in the study. Results were analyzed using mean, standard deviation and t-test. From the finding, it was observed that the use of a problem solving approach enhanced the achievement of the students in mathematics.

Olowa (2009) carried out a study to compare a problem solving approach with traditional teaching method in Science education in secondary school. Analysis of the results indicates that the problem-solving method of teaching is more effective than the traditional approach. The current study therefore investigated the effect of a problem solving approach of teaching on Asuom Senior High School students' performances in solving algebraic linear equation word problems.

2.3 Teachers' Role in Problem Solving Instruction

Teachers' role starts before students begin to work on the problem and continue until the end of the process. Teachers should guide their students to solve problems in mathematics but not to do all the process for them. It should be remembered that problem solving is a process and students should learn this process by solving problems on their own. It is important to note that if students know the way to solve a problem, they could apply it any time. Solving a problem successfully make the students happy, confident and smart. The teacher emphasis on understanding the problem before the solution process. This required that students read the problem carefully. This is necessary, especially for students with reading difficulties. This means that teachers should emphasise on the importance of reading a problem carefully. Teachers also should make sure that students understand the problem before they embark on the solution process. This can be done by asking students to restate what the question is asking for in their own words. The teacher also discusses any unfamiliar terms or phrases in the problem statement, and ask students to restate the problem in their own words. Teachers should clarify the task at hand to students. Teachers should listen carefully to students' thoughts and discussions; observing the dynamics of group work and questioning individuals or groups about the strategy they are using and their findings. Teachers should ask students questions to help them clarify the direction they are taking to solve the problem. They should also provide hints to students who need them.

Allevato and Onuchic (2007) suggested and explained the teachers' role in a problem solving instruction as follows:

- Form groups and hand out the activity. The teacher presents the problem to the students, who put themselves into small groups, read and try to interpret the problem in their own words. It should be emphasized that the mathematical content needed to solve the problem has not yet been presented in class. The problem proposed to the students will lead to the content that the teacher plans to construct in that lesson.

- Observe and encourage. The teacher will not be the only source of knowledge, while students attempt to solve the problems, the teacher observes, analyses students' behavior, and encourage collaborative work. The teacher mediates in the sense of guiding students to think, giving them time to think, and encouraging the exchange of ideas among learners.

- Help with secondary problems. The teacher encourages students to use their prior knowledge, or skills that they already know to solve the problem, and encourage them to choose different methods based on the resources available. Nevertheless, it is important to help students with their difficulties, intervening, questioning, and following their explorations, and assisting them to solve secondary problems when necessary. These refer to doubts presented by the students in the context of the vocabulary present in the problem statement, in the context of reading and interpretation, as well as those that might arise during the solution process, e.g. notation, the passage from text to mathematical notations, related concepts, and operational techniques, to enable the continuation of the solution process.
- Write solutions on the board. Representatives of the groups are invited to present their solutions on the board. Correct as well as incorrect solutions, as well as those done for different processes, should be presented for all the students to analyze and discuss.
- Plenary session. The teacher invites all students to discuss solutions with their peers, to defend their points of view and clarify doubts. The teacher acts as a guide and mediator in the discussions, encouraging the active and effective participation of all students, as this is the richest moment for learning.
- Seek consensus. After addressing doubts and analyzing resolutions and solutions obtained for the problem, the teacher attempts to reach a consensus with the whole class regarding the correct answer.
- Formalize the content. At this moment, the teacher makes a formal presentation of the new concepts and contents constructed, highlighting the different operative techniques and properties appropriate for the subject.

- It can be seen from the seven steps outlined that, in a problem-solving approach of teaching Mathematics, the problem is presented to the students before the mathematical content needed for solving it is formally presented by the teacher. Also, guiding and facilitating can be critical aspects of engaging all Mathematics students. Sometimes though, as teachers, we fail to give students the uninterrupted time they need to engage in collaborative problem solving, mathematical reasoning, and productive struggle. All students must be encouraged to lead discussions of their strategies, making their thinking public, with the whole classroom valuing potential mistakes and errors, and using students' mathematical ideas as teachable moments and basis for later success (NCTM, 2018). Teachers have an important role to play in assisting all students to engage in deep mathematical reasoning during problem solving instruction. The ultimate aim of a problem-solving approach in teaching Mathematics is to enable students to develop an understanding of concepts and procedural skills in Mathematics, thereby enhancing their academic performance.

2.4 Problem

A problem is a task such that a path to the solution is not readily apparent to a problem solver (Mayer & Wittrock, 2006). Most word problems in mathematics textbooks are verbal translations of symbolic exercises that are transparent and can be solved without much struggle. According to Schoenfeld (1983), a problem is only a problem if the problem solver does not know how to go about solving it. A problem that can be solved comfortably by applying a routine or familiar procedures (no matter how difficult) is an exercise. A problem is a situation that confronts a person, that requires resolution, and for which the solution path is not immediately known

(Krulik & Posamentier, 1998). This implies that if a situation is called a problem, then, there should be a challenge to solve it. Schoenfeld (2011) argued that a problem depends on the relationship between the 'problem' and the 'problem solver'; a task that can be a problem for someone, may be an exercise for another person. Hence, what generally makes a task a problem is the amount of challenge required to solve it. If a task is not challenging, or can be solved by applying a known procedure or formula, it is considered as an exercise. According to Zeitz's (1999), the difference between an exercise and a problem is that, an exercise is a question which can be solved by applying a routine procedure or formula. When solving an exercise, a learner does not need to apply specific techniques or puzzling out choosing techniques to use. On the other hand, solving a problem requires critical thinking skills and resourcefulness before the right approach is obtain. Sidney (1992) added that, a problem is a task that presents a challenge that the problem solver accepts. It must also be a task the learner do not readily see a way to solve it, but there is willingness to solve it. In the context of Mathematics education, a problem is a task that requires mathematical skills, concepts or process used to arrive at a goal.

2.5 Problem Solving

Problem solving is a complex cognitive task in which critical thinking and metacognitive activity play a crucial role. Oyarole (2012) described problem solving as the steps taken by a problem solver to search for solution(s) to problem(s). It is an approach where by students learn to use their prior knowledge to build on skills and concepts for themselves. It is a method concerned with the creative thinking of everyday life. Problem solving is a vehicle through which students can achieve the functional, logical and important values of Mathematics (Taplin, 2006). Montague (2003) described mathematical word problem solving as a process involving two stages: "problem representation" and "problem execution". Both problem representation and problem execution are necessary for problem solving. Successful problem solving is not possible without first representing the problem appropriately. Appropriate problem representation indicates that the problem solver has perceived the problem and serves to guide the student toward the solution plan. Actively reading a problem allows students to make sense of it; however, the depth and quality of students' decoding and subsequent understanding of the text affect their success (Pape, 2004). To solve a word problem, individuals must manage both the text and the Mathematics encoded within the text (Vilenius-Tuohimaa, Aunola, & Nurmi, 2008). One's reading ability influences how likely an individual will solve a word problem (Vilenius-Tuohimaa et al., 2008) and similarly, one's knowledge of Mathematics influences how well an individual deciphers Mathematics texts (Pape, 2004). A problem is a question whose process for answering it is unclear.

National Council of Teachers of Mathematics (NCTM, 2009) described problem solving as getting involved in a task for which there is no immediate answer. Problem solving is fundamental in Mathematics education. Academic achievement in Mathematics is greatly influenced by a students' active participation in the learning process. It is universally acknowledged that problem solving is critical for success in learning Mathematics. Learning to solve word problems involves knowledge of semantic construction and mathematical relations as well as knowledge of basic numerical skills and strategies. Yet, story problems pose difficulties for many students because of the complexity of the solution process. Anderson, Sullivan, and White (2004), described problem solving as the process by which students explore non-routine questions. The explorations involve using different strategies to solve unfamiliar tasks, as well as developing the processes of analyzing, reasoning, generalizing and abstracting.

Nafees (2011) explained that, problem solving is a process of solving mathematical problems through higher-order cognitive operations of visualizing, abstracting, comprehending, manipulating, reasoning and analyzing. It increases students' self-confidence to think mathematically and improve their problem solving skills in general. Teachers are therefore required to use instructional strategies and activities that will develop critical thinking and problem solving skills in students. Schoenfeld (2013) definition of problem solving consists of three components that direct students' understanding: the existence of a solution is uncertain making sense of the problem situation and the means necessary for making decision. In general, problem solving is tackling a problem that does not have a known solution. Mathematical problem solving can be broken down into two major parts: *problem representation*. Thus, converting a problem from text into an internal representation, and a *problem solution*, applying the legal operators of Mathematics to the internal representation to arrive at a final solution. Hegarty, Mayer, and Green (1995) stated that students perform poorly on word problems even when they perform well on corresponding arithmetic computation, suggesting that problem comprehension is the main source of students' difficulties. Montague (2003) added that, good problem solvers use a variety of processes and strategies as they read and represent the problem before they make a plan to solve it. First, they read the problem for understanding. As they read, they used comprehension strategies to translate the linguistic and numerical information in the problem into mathematical notations. They paraphrase the problem by putting it into their own words. They identify the important information and may even underline parts of the problem. Good problem solvers ask themselves what the question is and what they are looking for. Visualizing or drawing a picture or diagram means developing a relationship among all the important parts of the problem. They hypothesized by thinking about logical solutions and the types of operations needed to solve the problem. They may write the operation symbols as they decide on the most appropriate solution path and the algorithms they need to carry out the plan. They ask themselves if the plan makes sense given the information they have.

Van de Walle (2004), described problem solving as a principal instructional strategy used to fully engage students in an important Mathematics learning situation. It also goes beyond the domain of Mathematics to include everyday life activities in general. Successful problem solvers usually construct a mental model of the problem situation and solve the problem based on this model. Solving a problem successfully makes a student happy, confident and smart. Problem solving has the ability to make a student feel smart and confident.

According to Charles, Lester, and O'Daffer (1987). the reasons for teaching problem solving are:

- To develop students' critical thinking skills
- To develop the abilities of students to select and use problem solving strategies.
- To develop desirable attitudes and beliefs about problem solving
- To develop students' abilities to use related knowledge to situations.
- To develop students' abilities to monitor and evaluate their thinking and progress while solving problems.
- To develop students' abilities in cooperative learning situations.

- To develop students' abilities to find correct answers to a variety of types of problems.

All students need to create new mathematical knowledge through problem solving, solve problems that arise in mathematics and apply a variety of appropriate methods to solve problems and monitor and reflect on the process of problem solving in mathematics. It necessary for students to know how to solve a problem not just finding the answer. Knowing how to solve a problem is ability to use problem solving strategies in an appropriate situation. This also increases the possibility to solve any problem.

2.6 Solving Word Problems

Word problem is a verbal description of a problem situation wherein one or more questions are asked in which the answer(s) can be obtained by the application of mathematical operations to numerical information available in the problem statement (Verschaffel et al., 2000). Word problem is a combination of numbers and words in which students apply Mathematics instruction in the context of problem solving (Pfannenstiel, Bryant, Bryant, & Porterfield, 2015). Word problems are designed to help students apply Mathematics concepts to real-life situations. The solution of word problems depends on the ability of student's reading comprehension, recognition of implied or stated operations, identification and quantification of stated or implied relationships within the problem statement, selection and use of visual aids such as sketches, translation of written language into equation, and application of learned mathematical manipulative procedures to solve the equation. Word problems are used to train and test students' understanding of the underlying mathematical concepts within a descriptive problem, instead of testing only their manipulation skills.

Effective problem solvers often reread texts, make and revise their situation models before settling on the appropriate one (Verschaffel et al., 2000). Students who can implement more than one representation to solve a word problem are more likely to solve it than their peers who know only one way (Bostic & Pape, 2010).

In the context of the Mathematics curriculum, a word problem requires the use of mathematical skills, concepts, or processes to arrive at the answer. According to Oviedo (2005), solving word problem requires the ability of students to read, interpret and transform the stated words within their context into a mathematical statement before embarking on a search for computational strategies. Solving word problems is complex because the multiple components comprising problem solving do not necessarily follow a strictly linear model (Depaepe, De Corte, & Verschaffel, 2010). Depaepe et al. summarized problem solving as understanding and defining the problem situation, constructing a mathematical model of the relevant elements, relations, and conditions embedded in the situation; working through the model to derive some mathematical results interpreting the results with the original problem situation, check if the answer is appropriate and reasonable for its purpose.

The problem solving process also has an influence on the student's ability to solve mathematical word problems. Tajika (1994) proposed that the process of solving word problems involve four cognitive phases. These are translation, integration, planning, and execution. The translation phase generally refers to the initial reading of the problem during which the problem solver creates an internal representation of the individual propositions in the text, relying heavily on reading comprehension. The integration phase requires the problem solver to select the relevant information from the text to coherently represent the problem as a whole. This often involves the identification of relationships between variables in the text. During the planning phase, the problem solver generates a plan for solving the problem by breaking it down into a series of steps, often requiring the creation of mathematical representations of the text. Finally, the arithmetic computations are carried out during the execution phase.

Jerry (2014) proposed eight factors that affect students' word problem solving ability. These are:

- ability to read and comprehend written text in the word problem
- ability to identify written clues indicative of mathematical operations
- ability to identify geometric objects referenced in the written text and to draw an appropriate sketch to match the problem statements
- ability to recognize relational statements between parts of the written text
- ability to select the applicable formula based on the problem context,
- ability to translate written text into mathematical equations
- ability to apply manipulative problem solving procedures to arrive at a correct response
- ability to distinguish between correct and incorrect solutions based on problem constraints.

In order for students to solve algebraic word problems successfully, they should be able to read written mathematics and understand what the text is all about. The student begins the word problem solving task with the reading of one or more written statements framed within a real-world problem context. Solving algebraic word problems involves a combination of one's knowledge of sentence structure, mathematical relations, basic numerical skills, and mathematical strategies (Griffin &

Jitendra, 2009). Equipping students with the essential tools in mathematics requires teachers to empower students with reading, comprehension and mathematics strategies so that they may be effective at problem solving. Exposing students to problem solving strategies will help them become good problem-solver.

2.7 Students' Difficulties in Solving Word Problems

Many students lack problem-solving skills because they are unaware of the problem solving strategies available to help them in solving word problems (Chamot & O'Malley, 1994). Problem solving is a difficult task for many students as it involves a lot of steps. Students have to struggle in going from one step to another although the steps may not necessarily have to be followed in sequential order. Some of the processes in solving word problems involve reading comprehension and how students make a plan. In order for students to acquire learning gains in mathematics, teachers need to know the challenges that impede students from understanding and solving mathematical word problems. Ilany and Margolin (2010) indicated that students' difficulties in solving Word Problems were due to the existence of the knowledge gap between Mathematics language and natural language, and knowledge gaps between the textual unit and the hidden mathematical structure. Ilany et al. (2010) further stated that the difficulty with the solution of mathematical word problems is the need to translate the event described in natural language to arithmetic operations expressed in mathematical language. The translation from natural language includes the syntactic, semantic, and pragmatic understanding of the discourse. The vocabulary aspect of the problem can be challenging. Sometimes, students do not comprehend the meaning of particular words in text and this makes them feel frustrated and think that the problem is difficult to solve. The difficulty of translation highlighted the necessity that the student should be able to identify the textual clues suggesting specific mathematical operations and be able to understand the 'literal clues', that is the words that support (*helpful clues*) or the words that deceive (*misleading clues*), as clues for choosing the arithmetic operations needed to solve the problem (Ilany et al. 2010, p. 143). Correct identification of the mathematical operations in the Algebraic Word Problem (AWP) text is fundamental to the subsequent creation of the equation(s) to be solved in the complete algebraic word problem solution process. Students fail at problem solving because they are not equipped with the needed tools to learn how to solve word problems. Hence, students need mathematics strategies, reading and comprehension techniques.

Hegarty et al. (1995) suggested that significantly more cognitive processing of mathematical knowledge occurred as the student works from written text to solve word problems than from solving standard equations. Bishop, Filloy and Puig (2008) argued that word problems have traditionally been very difficult for many students in algebra classrooms. The basic source of difficulty for students in solving algebraic word problems is translating the story into right expressions or equations (Bishop et al., 2008). Bishop et al. (2008) further argued that, the difficulties students encounter when translating word problems from natural language to algebra and vice versa is one of the situations that generally arise when students have just completed elementary education and are beginning secondary education. Pape (2004) identified three types of errors associated with word problem solutions: A *reversal error* occurred when the opposite operation was used in solving the problem, a *linguistic error* occurred when a computational step indicated in the text was omitted, and a *Mathematics error* occurred when the student misinterprets a mathematical relational statement or operation. Portal and Sampson (2001) stated that students find it difficult to solve word problems because they are not sure and cannot decide on what operation to use. They further argued that although Mathematics is the most indispensable tool, many students try to learn it without much success because they manipulate word problem according to memorized rules with little or no meaning.

Yeo (2009) indicated that some students have low progress in solving word problem due to their inability to translate the problem into mathematical symbols. Some students also have difficulties in solving word problem because they do not understand the problem as they find the problem confusing. When students fail to translate word problems into equations correctly, they end up with wrong solutions (Dela-Cruz & Lapinid, 2014). The difficult part of solving mathematics word problems appear to be the process of understanding the problem and deciding what operation(s) need(s) to be carried out in a certain problem (Sepeng & Madzorera, 2014). This implies that success in solving algebraic word problems require students to gain familiarity with the vocabulary of Mathematics before they can solve word problems effectively. Sepeng (2013) observes that solving algebraic word problems is difficult for many students because of the unrealistic strategies that they tend to employ in solving these problems. Sepeng goes further to acknowledge that in order to successfully solve algebraic word problems, students 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. Lumpkin and McCoy (2007) observed that students' incorrect responses to word problems could be attributed to an error in one of three places along the problem solving process: an incorrect interpretation of or inability to understand the problem, flaws in the setup of the problem, and/or errors in computation. Fajemidagba (1986) investigated factors responsible for students' poor performance in mathematics word problem. Factors identified included misconception of mathematical statement, lack of understanding which led to errors. Fajemidagba

(1986) identified two types of reversal errors usually committed by students when solving word problems. These are static syntactic error and semantic error. According to Fajemidagba (1986), the static syntactic error is committed due to direct translation of the given problem. The semantic error could be committed as a result of inadequate understanding of the language embedded in the problem.

A study conducted by Aniano (2010) revealed that the level of difficulties in translating phrases to mathematical symbols was one of the factors that determine the problem solving skills of students. Burton (1991) argued that the transformation of word problems into arithmetic or algebra causes great difficulty for many students. This view was supported by Vista (2010), that students' comprehension in translating phrases into mathematical symbols affects their performance in problem solving. Students make errors in translating word problems from the natural to the mathematical language due to lack of command of the English language, that is, they are not able to construct a meaningful body of knowledge from the information in the question, including data and a solution scheme (Ilany et al., 2010). Many studies have detected some difficulties students faced when solving word problems. These are:

- the difficulty of operating with unknowns (Filloy, Rojano, and Puig, 2008).
- the tendency to interpret the equal sign as an indicator of a result, as opposed to a relation between two quantities (Knuth, Alibali, Mcneil, Weinberg, and Stephens, 2005)
- the difficulty of understanding the use of letters to represent unknown(s) (Booth, 1984).

- the complexity involved in transforming the verbal formulation into an appropriate equation. This problem has been associated with the syntax of the verbal formulation (Fisher, Borchert, & Bassok, 2011).

Most students often encounter difficulty with correctly identifying the meaning of mathematical terms and phrases, leading to incorrect representations of the context, hence, present incorrect solutions. Yerushalmy (2006) stated, 'In solving contextual problems, construction of a symbolic system for real-world knowledge is a complicated task because knowing the actual phenomenon cannot be easily manifested in symbolic language, even when one is familiar with the language.'

Most students also apply the direct translation or keyword strategy as a means computational shortcut for solving word problems. In this approach, students typically read the problem, select what appear to be keyword(s) from the problem statement, and try to fit them together into an algorithm. Therefore, when reading a word problem, students frequently look for only key words to solve the problem. This is only moderately successful in that typically, key words can only be used with one step, simple problems (Marshall, 1995). The system breaks down as problems become more complex requiring several operations to solve them. Moreover, the key word strategy can sometimes be misleading because the underlying semantic structure of the problem may be contrary to the key word used (Reed, 1999). The unique features of problem solving approach which distinguished it from the traditional teaching approach were: the group learning approach; the nature of student involvement and participation in lessons; the guiding and facilitating role of the teacher; the social interactions that exist in the classroom; availability of scaffolds and problem solving strategies; the prevalence of interactive learning environment and students critical responses of other students contributions through exploratory talks.

2.8 Cooperative Learning

Cooperative learning is an instructional approach whereby students work in small groups to help one another learn academic material. In this approach, students are required to assist one another find solutions to questions, rather than seeking answers from their teacher (Yamarik, 2007). This was supported by Siegel (2005) that cooperative learning involves groups of learners working to solve a problem, complete a task or accomplish a common goal. Cooperative learning allows students to think through the solution process, and provide both the teacher and students opportunities to identify and correct mistakes and misconceptions, rather than the teacher alone doing all the thinking for the students. In thinking through a process, a student communicates with him/herself and when speaking that process aloud, a meaning is conveyed to which others are able to contribute, leading to a harnessing of ideas that facilitates building of knowledge individually and collectively (Sfard, Forman, & Kieran, 2001).

Cooperative learning is a key instructional strategy when implementing a problem solving approach of teaching. When students work in groups, they share responsibilities and ideas. Consequently, they may be more successful in finding solution to a given task. According to Vygotsky (1978), students are capable of performing at higher intellectual levels when they work in groups than working individually. An important feature of cooperative learning strategy is that, the success of one student helps other students in the group to be successful.

In the classroom setting, the term ‘group work’ implies that students are engaged in a coordinated continuing attempt to solve a problem or in some other way construct common knowledge (Mercer & Littleton, 2007). Adding their voice to the benefits of cooperative learning, Barkley, Cross and Major (2005), assert that cooperative arrangements were found superior to either competitive or individualistic structures on a variety of outcome measures, generally showing higher achievement, higher-level reasoning, more frequent generation of new ideas and solutions, and greater transfer of what is learned to new situations. Ma (1999) contends that students are better able to conceptualize mathematical word problems by discussing or explaining the underlying concepts to others to discover different ways of solving them.

Masingila and Prus-Wisniowska (1996) assert that when students are encouraged to discuss mathematics concepts with other students, and with their teacher, they have opportunities to explore, organize, and connect their thinking. Research suggests that students’ participation and active involvement in Mathematics lessons enhance their understanding of subject (You, 2014). Dhlamini (2012) emphasises three elements of cooperative learning activities, namely, discussion, argumentation and reflection. Lai (2011) also added that group learning activities such as, providing elaborated explanations to group members enhances students’ understanding of the concept learned. Many conditions may add to fostering a culture of critical thinking that supports mathematical discussions in small groups. A fundamental condition is that, the classroom environment is supportive and students are more comfortable to share their problem solving process with their peers. During the group discussions, learners through exploratory talk were able to identify and correct the errors they made through the scaffolds in the form of support provided by the other capable learners in the group. Ernest (1996), stated that meaningful learning is not just a passive absorption of information but rather more interactive. Piaget (1970) indicates that students' interactions in the classroom can enhance knowledge development because interaction can create cognitive conflict that can change student's thinking. Piaget holds the view that, peer interactions stimulate student's reflection about ideas that other students present. When students learn in small groups, there is an exchange of thoughts and information among the members of the group (Pai, 2012). They generate different methods to solve the problem, increase their ability to translate word problems into equations and develop an exchange of ideas that they share. According to Franke, Kazemi, and Battey (2007), individuals do not exist in isolation but learn within a social setting in which understanding is co-constructed with other members. Bruner (1985) argues that cooperative learning strategies enhance students' problem solving abilities because the students are confronted with different interpretations of the given situation. In general, students benefit academically and socially from cooperative, small-group learning (Gillies, 2002). learning mathematics is most effective when students are directly involved in problem solving activities and measurement of learning is based on the ability of students to solve problems and use knowledge to facilitate critical thinking in real life situations (Ngussa & Makewa, 2014). However, cooperative learning strategy requires proper supervision by the teacher to avoid unproductive learning outcome as a results of students' engaging in unproductive discussions rather than the task given to them.

2.9 Traditional Teaching Approach

Traditional teaching approach is an instructional strategy where lessons are delivered by given a set of rules to students to be followed without the students knowing how those rules came about (Akyeampong et al., 2013). In this approach, active participation of students during teaching and learning is not encouraged. Hence, turn students to passive receivers of information. According to Bello (2014), traditional teaching method is an instructional strategy where the teacher's role is to present information that is to be learned to the students. It is described as a one-way flow of information from the teacher who is always active, and the students are passive receivers of the information. In traditional teaching strategy, concepts and procedures are usually taught first, then the students practice what they learned through solving routine problems (English, Lesh, & Fennewald, 2008). The traditional teaching strategy focuses more on direct instruction and lectures, students learn through listening and observation. This instructional approach emphasises more on getting facts rather than understanding mathematics concepts. The idea is that, there is a fixed body of knowledge that the students must come to know. The teacher seeks to impart mathematics knowledge to the passive students, leaving little room for students initiated questions. This approach of teaching is often boring because the job of student in the classroom is to sit and watch the teacher solve mathematics problems on the chalkboard and then copy the teacher's solution.

Students' understanding of Mathematics concepts is improved when they make connections, organise, clarify and reflect on their thinking, and with traditional Mathematics instruction, these do not happen. Presentation of lecture without given opportunity for students to interact among themselves and with the teacher can be ineffective regardless of the skill of the teacher. Traditional teaching strategy has been reported to be less effective to the demands of high rates of cognitive and affective outcomes (Slavin, 2011). This view was supported by Clement (2013) that the traditional teaching approach in classroom has limited effectiveness in the teaching and learning process. The use of traditional teaching method makes learning boring for students since they are to watch the solutions of mathematics problems on the chalkboard and then copy them without proper understanding. At the end of the day, students may not be able to apply the knowledge of mathematics acquired in the classroom to real life situations.

2.10 Summary of Literature Review

The literature in this chapter suggests that a problem solving approach to teaching is a student-centered approach to the teaching of Mathematics. The literature review also indicates that, problem solving approach of teaching is effective in terms of improving students' understanding of Mathematics concepts than the traditional teaching strategy. Problem solving approach encourages students' active participation in the teaching and learning process which develop them critical thinking and problem solving skills. The finding of most of those studies concluded that academic performance is enhanced by employing effective instructional methods which recognize active participation of students in the teaching and learning process.

Furthermore, the literature review indicate that students success in solving word problem depends on their ability to read, interpret and transform the stated words within their context into the correct mathematical statement before mathematical computations are carried out. The literature further indicate that translating the verbal descriptions into mathematical symbols and operations is the major challenge that many students encounter in the process of solving word problems.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter provides details of the methodology that was used to carry out the study. These are: research design, population, sample and sampling technique, research instruments, validity, pilot study, reliability, data collection procedures and data analysis techniques.

3.1 Research Design

A research design is a detailed outline of how an investigation or a study would be carried out. It includes, data collection procedure, instruments used for data collection and the intended means for analysing data collected. A research design provides insight into how to conduct a research using a particular research methodology. Polit and Beck (2012) described a research design as the means for a researcher to answer the research question or to test the research hypothesis.

The current study employed a quasi-experimental non-equivalent pre-test and post-test control group research design using a mixed method. Gay, Mills and Airasian, (2011) defined a non-equivalent control group design as a type of quasi-experimental research design that lacks random assignment of subjects to the control and experimental groups. According to Cook (2002) random assignment is rare in research on the effectiveness of teaching approaches to improve students' performances.

The non-equivalent pre-test and post-test control group research design was chosen because it would offer practical options to work with intact classes in both control and experimental groups In addition, this design was adopted since the study was conducted in a classroom setting and it was not possible to randomly assign participants to control and experimental groups. Also, this design was opted in order to ensure that participating students continued learning other subjects according to their schools time-tables and also take part in any other school related activity in their schools. It also allowed the researcher to evaluate the effect of the treatment (Problem Solving Approach) on participants in their natural environment.

The researcher used a mixed method because there is more insight to be gained from using both quantitative and qualitative research method than using either quantitative or qualitative method. Cohen, Manion, and Morrison (2004) argued that, the use of both qualitative and quantitative data and data analysis permit researchers to simultaneously make generalizations about a population from the results of a sample and to gain a deeper understanding of the problem investigated.

The variables of this study were categorised into independent and dependent variables. The independent variable was the treatment in the control group and experimental group, and the dependent variable was the post-test scores of students. The researcher taught the experimental group using problem-solving approach whilst the control group was taught by their incumbent mathematics teacher using the traditional teaching strategy. The pre-test scores obtained from both groups were used to establish a baseline for measuring the effects of each of the teaching approaches.

3.2 Population

According to Best and Kahn (2007), a population is any group of individuals who have one or more characteristics in common that are of interest to the researcher. The population for this study was made up of all first-year students in the Gold Track of two public senior high schools in the 2018/2019 academic year. These schools were chosen because their students were admitted through the computerized placement system and hence ethnically homogenous. In addition, both schools are mixed with day and boarding facilities for students. These schools are located in the Kwaebibirem Municipality in the Eastern Region of Ghana.

3.3 Sample and Sampling Technique

Sampling is the process through which a portion of the population of a study is chosen to represent the entire population (Seidu, 2015). Purposive sampling technique was used to select two senior high schools in the Kwaebibirem Municipality of Eastern Region of Ghana. These schools were chosen because the researcher had been teaching in the municipality for quite a long time and is familiar with the social and academic environment of the area.

Seidu (2015) described simple random sampling as a sampling technique that offers equal opportunity for all members in a population for being selected. Simple random sampling technique was used to select one intact class from each of the participating schools. The sample size for the present study consisted of fifty-two (52) students of which twenty-two (22) were in the control group and thirty (30) in the experimental group. The control group was made up of eight (8) boys and fourteen (14) girls while the experimental group consisted of seventeen (17) boys and thirteen (13) girls. The ages of the students in both control and experimental groups ranged between fourteen (14) and seventeen (17) years.

3.4 Research Instruments

Research Instruments are devices used by researchers to collect data for their studies. Annum (2017) described research instruments as tools such as a test, questionnaire, or interview guide used for data collection in a study. The instruments used for data collection in this study were: pre-test (see Appendix A), post-test (see Appendix B), questionnaire and an interview guide.

3.4.1 Pre-Tests

A pre-test was administered to all the participating students before the start of the experiment. The pre-test was used to measure and compare the performance levels of students in both groups (control and experimental) prior to the commencement treatment. The pre-test questions consisted of ten (10) items involving algebraic linear equation word problems (see Appendix A). The test was conducted during the normal teaching period. The students were required to answer all the questions within one hour. In administering the pre-test, each student in the classroom was given a printed question paper and an answer sheet. Their scripts were then collected after the one hour duration and marked by the researcher using a prepared marking scheme (see Appendix A1). Each question correctly answered was scored a maximum of 4 marks, given a total of forty (40) marks on the whole test. The results of the pre-test helped the researcher to identify the difficulties students faced in the process of solving algebraic linear equation word problems and also ascertain the level of equivalence prior to the commencement of the treatment between the control and the experimental groups.

3.4.2 Post-Test

Students in both control and experimental groups were post-tested after the treatment. The post-test was meant to measure the effect of each teaching method (Traditional and Problem Solving approaches) on the performance of students. The post-test also consisted of ten (10) test items which were similar to the pre-test questions. All conditions during the post testing were the same as the pre-testing except that only the test items were not the same (see Appendix C). In order to provide an accurate measure and consistency in scoring the post-test, the scripts of both control and experimental groups were marked by the researcher using a prepared marking scheme (see Appendix C1). The post-test was also marked out of 40.

3.4.3 Questionnaire

A questionnaire is a printed list of questions, purposely designed to get the views or opinions of respondents' about an issue, product or service (Annum, 2017). Questionnaire was chosen as one of the research instruments which was answered by the students in the experimental group. It was chosen in order to obtain views of students about the problem solving approach of teaching. The questionnaire had four closed-ended questions for students to respond. Thus, AGREE, UNDECIDED or DISAGREE (see Appendix. D).

3.4.4 Interview Guide

An interview is a conversation carried out between interviewer and interviewee with the aim of getting a specific information through the responses of the interviewee (Osuala, 2001). According to Fox (2009), there are three types of interviews: structured, semi-structured and unstructured interviews. A structured interview is an interview where questions are prepared in advance to help the interviewer ask the respondents the same questions in the same way. Such questions are geared towards obtaining a specific response from a respondent. An unstructured interview is an interview in which there is no specific set of questions prepared in advanced, although the interviewer usually has certain topics in mind to ask during the interview. Semi-structured interviews are similar to structured interviews in that the questions to be asked are prepared in advance, but instead of using closed questions, semi-structured interviews use open-ended questions (Fox, 2009).

The researcher carried out an unstructured interview with 6 (six) students in the experimental group to solicit their views regarding the use of the problem solving approach of teaching. The interviewees consisted of two students who performed well in the post-test; two students who performed averagely, and two students who obtained low marks in the post-test. All the six students were asked the same interview questions. The unstructured interview guide only outline the topics to be discussed with the students. The responses given by students were written down in the form of short notes.

3.5 Validity

Validity is the degree to which a test measures what it is intended to measure. It is an assessment of the appropriateness of a measuring tool. Validity of a research instrument evaluates the extent to which the instrument measures what it is designed to measure (Robson, 2011). The test items were given to experienced teachers in the Mathematics department of Asuom senior high school to ascertain the content, construct and face validity of the items. Two of the test items were revised based on their suggestions before the pilot study.

3.6 Pilot Study

A pilot study is a small-scale, preliminary study which aim to investigate whether vital components of a main study will be feasible. It is a way of checking whether questions work as intended and are understood by participants who may respond to them. Pilot study also helps the researcher to identify unforeseen errors in the test items before data collection and hence, further strengthens the reliability of the research findings. Dillman (2000) asserts that pilot testing of research instruments helps to ensure the validity and reliability of the data it collects.

The pilot study was carried out with students in the Green Track of the school where the main study was conducted. The pilot sample consisted of nineteen (19) students (13 boys and 6 girls). The pilot sample had similar characteristics as those in the main study in terms of academic performance in mathematics. The sample that participated in the main study (Gold Track) were on vacation during the pilot study.

3.7 Reliability

According to Yakubu (2015), reliability is a "measure of consistency of research instruments to obtain the same result with the same measure" (p.63). The instruments were pilot tested to determine their reliability. Students in both control and experimental groups wrote a pre-test before treatment and a post-test after the treatment. The researcher prepared a marking scheme which was used in scoring students' responses to both pre-test and post-test items. The researcher himself marked all the scripts from control and experimental groups. Therefore, variations in making of test papers were reduced. The marked scripts were vetted by an experienced Mathematics teacher. The researcher himself marked all the scripts from control and experimental groups. Therefore, variations in marking of test papers were reduced.

The pre-test that was administered during the pilot study was used to calculate the reliability value of the test. The researcher used the split-half method to compute the Spearman-Brown reliability value of the test. In this method, the test scores were divided into two halves, usually using scores for odd-numbered items and scores for even-numbered items. Then, the correlation between the two halves was determined.

Spearman-Brown coefficient ranges from -1.00 to 1.00 with absolute values close to 1.00 indicating high consistency (Wells & Wollack, 2003). According to Cohen, Manion and Morrison (2011), Spearman-Brown split-half coefficient is high when its absolute value is at least 0.7. Spearman-Brown values of 0.81 and 0.76 were obtained for the pre-test and post-test items respectively and therefore a good reliability of the tests. Spearman-Brown formula for calculating reliability of test items is shown in APPENDIX G.

3.8 Data Collection Procedure

An introductory letter was obtained from the Post Graduate Coordinator of Mathematics Department of University of Education, Winneba. A permission letter was attached to the introductory letter which was given to the headmaster of the participating school, seeking his approval to carry out the study in his school. The headmaster granted an approval of the request and gave the researcher an acceptance letter. After the headmaster's approval, the researcher met the Head of Mathematics Department (HOD) and briefed him about how the study was going to be conducted and also asked for his support.

An arrangement was made between the head of Mathematics department of the participating school and the researcher. One first-year intact class (control group) was randomly selected to participate in the study. The researcher purposely selected the students in the school he teaches as experimental group because he wants to administer the treatment. Prior to the treatment, students in both control and experimental groups wrote a one hour pre-test, which consisted of ten (10) test items involving algebraic linear equation word problems, before the experimental group was subjected to treatment. The test was meant to reveal students' difficulties in solving algebraic linear equation word problems and also as a baseline for measuring the effects of the two teaching approaches (Problem Solving and Traditional Teaching). The treatment started after the pre-test and lasted for 3 weeks. The researcher taught the experimental group using problem solving approach and the control group was taught by their mathematics teacher using the traditional teaching strategy. A post-test was conducted immediately after the treatment. The post-test was administered in order to measure the effect of each of the teaching strategies on students' academic performance. An unstructured interview was also carried out on the experimental group to seek their views about the problem solving approach of teaching.

3.9 Treatment Procedure

The treatment lasted for three weeks with each week consisting of four periods (60 minutes per period). The treatment was designed in the form of lessons delivery in the classroom. The lesson plans during the treatment periods were based on Polya's (1945) heuristic steps of problem-solving. According to Polya (1945), good problem solvers usually go through four stages of problem-solving. These are:

- Understand the problem
- Devise a plan
- Carry out the plan
- Look back

Understand the problem, at this stage, students are expected to read through the problem statement for understanding, as they read, they use comprehension strategies to translate the linguistic and numerical information in the problem into mathematical notations. *Devise a plan,* at this stage, students generate a suitable solution plan for solving the problem by breaking it down into a series of steps, involving the creation of mathematical notations/formula from the text. *Carry out the plan,* mathematical computations are performed at this stage. This involves solving the problem step-by-step and if the solution is not found, the strategy is revised. *Look back,* at this last stage, the student checks the answer by plugging it into the original equation to make sure it is correct and make sense. Details of the treatment activities are shown in Appendix B.

3.10 Data Analysis Procedure

In this study, three research instruments were used: tests (pre-test and post-test) that produced quantitative data, questionnaire and an interview that produced a qualitative data. A pre-test was conducted to determine the performance of students in both control and experimental groups in solving algebraic linear equation word problems. A post-test was carried out after the treatment in order to ascertain the effects of a problem solving approach and a traditional teaching strategy. A questionnaire was administered to students in order to solicit their views on the effectiveness of the problem solving approach of teaching. An unstructured interview was carried out with the experimental group to determine their views about the effectiveness of the problem solving approach of teaching. The interview was conducted in order to complement students'. The analysis of the data was based on the research questions and hypotheses.

Research question 1 aimed at determining the difficulties students encounter in solving algebraic linear equations word problems, the researcher conducted a pre-test with the experimental. The researcher scrutinized the pre-test marked scripts of the students to determine their difficulties in solving linear equation word problems. Upon scrutiny, their difficulties were found, categorized and presented.

Research question 2 sought to determine the effect of a traditional teaching approach on students' performances in solving algebraic linear equation word problems. Research question 3 also sought to determine the effect of a problem solving approach of teaching on students' performances in solving algebraic linear equation word problems. The researcher conducted a pre-test and post-test with the control group. The results were presented in a frequency distribution table. The pre-test and post-test scores were further analysed using descriptive statistics, with the help of Statistical Package for Social Sciences (SPSS) to determine the effects of the traditional teaching approach and the problem solving approach on students' performances in solving algebraic linear equation word problems. A paired samples t-test was used to determine the difference in performance between the pre-test and post-test scores of each of the groups.

Research question 4 sought to obtain the views of students on the effectiveness of the problem solving approach of teaching. A questionnaire was administered to students in the experimental group to seek their views about the problem solving approach of teaching. The questionnaire was supported by an unstructured interview. Data collected from the questionnaire were analysed using frequencies together with their corresponding percentages. The researcher carried out an interview with six (6) students in the experimental group. The interview was meant to solicit students' views regarding the use of problem solving approach of teaching. Students' responses during the interviews were written down. The analysis was done using narrative style with direct quotations which revealed students emotions, and their thoughts about the use of problem solving approach during word problem solving lessons.

To test the null hypothesis that, 'there is no significant difference in performance between students taught algebraic linear equation word problems using traditional approach and problem solving approach', the researcher conducted a pre-test and post-test with both groups. The results were presented in a frequency table. The pre-test and post-test scores were further analysed using a t-test statistics to determine the effects of problem solving and traditional teaching approaches on both control and experimental groups. The pre-test and post-test scores of students were keyed into the Statistical Package for Social Sciences (SPSS version 21) software for the paired samples t-test analysis. The post-test scores of students in the control and experimental groups were keyed into the Statistical Package for Social Sciences software for the independent samples t-test analysis to determine if there is significant difference in performance between students taught algebraic linear equation word problems using traditional approach and problem solving approach.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The purpose of this study was to investigate the effect of Problem Solving Approach on senior high school students' performances in solving algebraic linear equation word problems. The study employed a quasi-experimental non-equivalent pre-test and post-test control group research design. The non-equivalent pre-test and post-test control group research design was employed because it offered practical options to work with intact classes in both control and experimental schools. Also, a quasi-experimental non-equivalent pre-test and post-test control group research design would ensure that participating students continued learning other subjects according to their schools time-tables and also take part in any other school related activity in their schools. The dependent variable was the students' scores in the post-test and the independent variables were the teaching approaches (Traditional Teaching and Problem Solving). Data for this study were gathered using both quantitative and qualitative methods. The quantitative data obtained from the pre-test and post-test scores were analysed using descriptive and inferential statistics. The pre-test and post-test scores of students were keyed into the Statistical Package for Social Sciences (SPSS) software for the analysis. The qualitative method of data analysis was used to analyse the data obtained from the questionnaire and the interview. The results of this study are presented, analysed and discussed based on the research questions and hypothesis. The present study was guided by the following questions:

1. What difficulties do students encounter in solving algebraic linear equations word problems?

2. What is the effect of traditional teaching approach on students' performances in solving algebraic linear equation word problems?
3. What is the effect of problem solving approach on students' performances in solving algebraic linear equation word problems?
4. What are the views of students about the problem solving approach of teaching?

4.1 Research Question 1: What difficulties do students encounter in solving algebraic linear equation word problems?

In order to respond to research question 1, a pre-test was administered to students in both control and experimental groups. The test comprised of ten (10) questions involving algebraic linear equation word problems. Each question correctly answered was awarded a maximum of 4 marks, given a maximum total score of 40 marks in the entire test. The pre-test was meant to reveal students' difficulties in solving algebraic linear equation word problems and also as the baseline for measuring the effects of the two teaching approaches (Problem Solving and Traditional Teaching). The pre-test scores of students in the experimental group are shown in Table 4.1

Table 4.1 Frequency Distribution of Pre-Test Scores in Percentages of Students in the Experimental Group

Scores	Number of Students	Percentage (%)
Below Average (0-19)	29	97%
Average (20-29)	1	3%
Above Average (30-40)	0	0%
Total	**(30) 100%**	**100%**

Source: Field data, 2019

The results in Table 4.1 indicates that out of the 30 (thirty) students who wrote the pre-test, 29 of them, representing 97% scored mars between 1 and 19, only 1 (one) student representing 3% scored a mark between 20 and 30 and no student scored between 30 and 40. This indicates that 29 (97%) of the students in the experimental group scored below the minimum average mark of 20, only one student obtained an average score and no student scored within the above average. Table 4.2 presents the descriptive statistic on the pre-test scores.

Table 4.2 Descriptive Statistics of Pre-Test Scores for the Experimental Group

	N	Minimum	Maximum	Mean	Std. Deviation
pretest	30	0.00	23.00	6.90	5.25

Source: Field data, 2019

The results in Table 4.2 showed that the minimum and the maximum scores of the pre-test were 0 and 23 respectively, out of 40 marks. The mean score of students in the pre-test was 6.90 and the standard deviation is 5.25. It was observed that students' performances was low, which implies that solving algebraic linear equation word problems was difficult for them. The pre-test marked scripts were scrutinized in order to obtain the challenges students' faced in the process of solving algebraic linear equation word problems. Upon scrutiny of the pre-test marked scripts, students' difficulties were found and put into four categories as shown in Table 4.3

Table 4.3 Students' Difficulties in Solving Algebraic Linear Equation Word Problems

Difficulty	Number of students	Percentage (%)
Lack of understanding of the problem	16	53 %
Misinterpretation of the problem	6	20 %
Computational errors	3	10 %
Application of Inappropriate Mathematical Knowledge	5	17 %

Source: Field data, 2019

The analysis of students' pre-test marked scripts indicate that, 16(53%) of the students did not understand the word problems statement hence, could not translate the sentences into correct equations in order to solve them. Six students (20 %) also misinterpreted the problem statement and therefore modeled wrong equations out of the verbal discerptions. Again, 3 (10%) of the students committed computational errors during the solution process and 5 (17%) misapplied mathematics knowledge, hence, presented incorrect solutions.

Lack of Understanding of the Problem

Majority of the students (53%) did not understand the word problems statement and therefore were unable to translate the verbal descriptions into correct equation in order to solve them. It seems the students did not understand what the question really wants them to do.

Figures 4.1 and 4.2 Show Students S1 and S2 Response to Pre-Test Item Number 7and 4 Respectively.

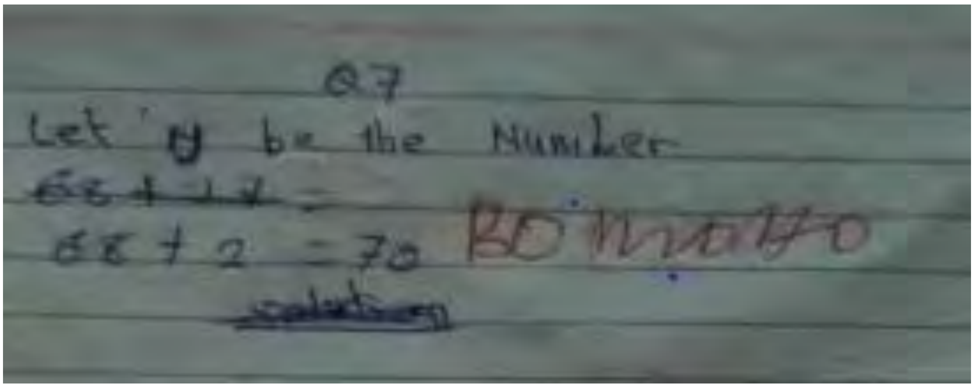

Figure 4.1 Answer showing lack of understanding of the problems

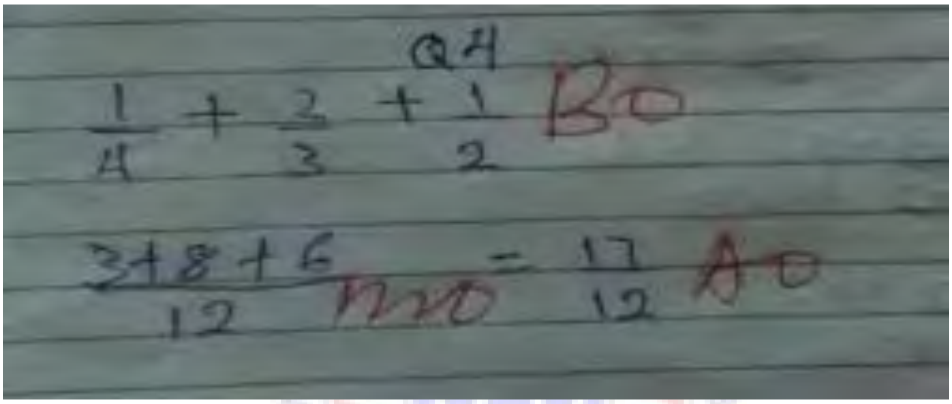

Figure 4.2 Answer showing lack of understanding of the problems

Figures 4.1 and 4.2 showed the incorrect response of students S1 and S2 who did not comprehend the problem statement. The question 7 required students to find two consecutive positive integers such that the greater added to twice the smaller gives 70. Student S2 did not understand the questions and just present any two numbers that add up to 70. The same happened with many students who attempted item numbers 2, 5, 6, 9 and 10. Test item number 4 required students to find an unknown number such that $\frac{1}{4}$ of the number added to $\frac{2}{3}$ of the same number gives $\frac{1}{2}$. The student didn't understand the question and just present only fraction. Students have difficulty with understanding English and Mathematics languages, hence, were unable to model correct equations out of the verbal descriptions.

Misinterpretation of the Problem

About 20% of the students misinterpreted the problem statement hence, modeled wrong equations out of them. For instance, pre-test item number 1 required students to find four consecutive odd numbers such that their sum was 168. Some of the students thought the solution must begin with odd numbers. For instance, a student misinterpreted the problem and wrote wrong equation for item number 1 as '$x + x + 1 + x + 3 + x + 5 = 168$' instead of the correct equation '$x + x + 2 + x + 4 + x + 6 = 168$'. The same happens with 9 out of 17 students who attempted the same question. Figures 4.3 and 4.4 show misrepresentation by students S3 and S4 in the pre-test.

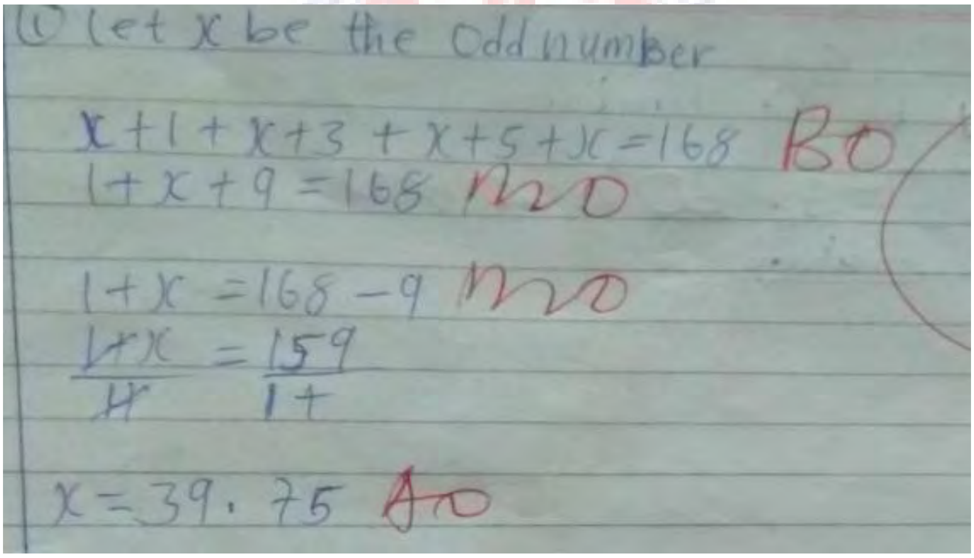

Figure 4.3 Answer showing misinterpretation of the problem by student S3

This response clearly showed that student S3 misinterpreted the problem statement and also didn't border to check whether the answer obtained makes sense.

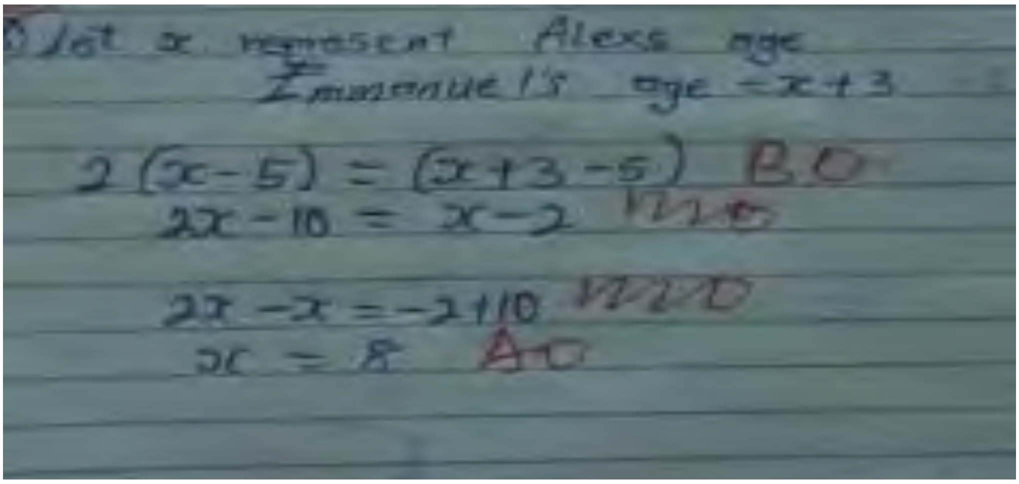

Figure 4.4 Answer showing misinterpretation of the problem by student S4

Computational Errors

About 10% of the students committed computational errors when they were solving the questions. These errors occurred as a result carelessness on the part of the students. These errors could have been corrected if the students had checked their solutions after they had gotten the answer.

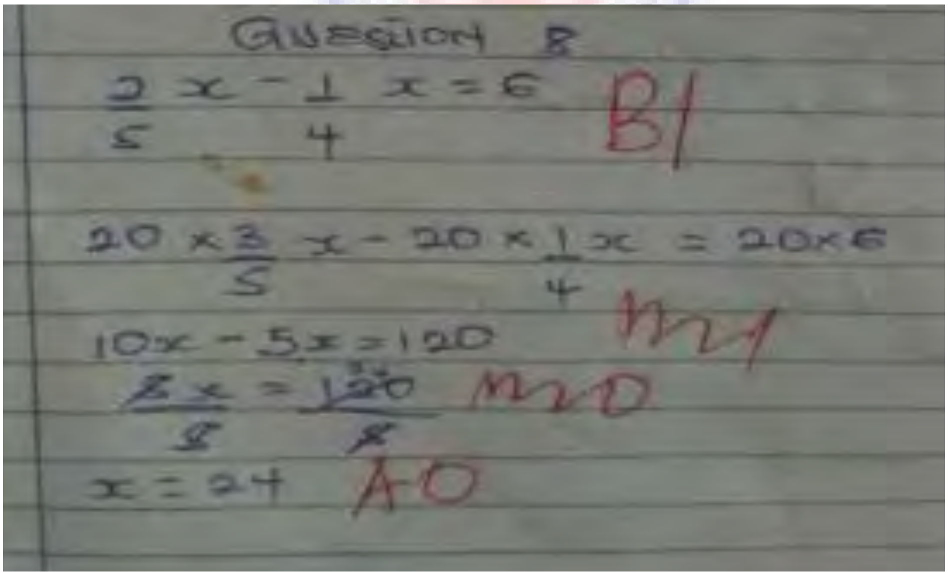

Figure 4.5 Shows response by a student, S5, to pre-test item number 8

Student S6 response to pre-test item number 9

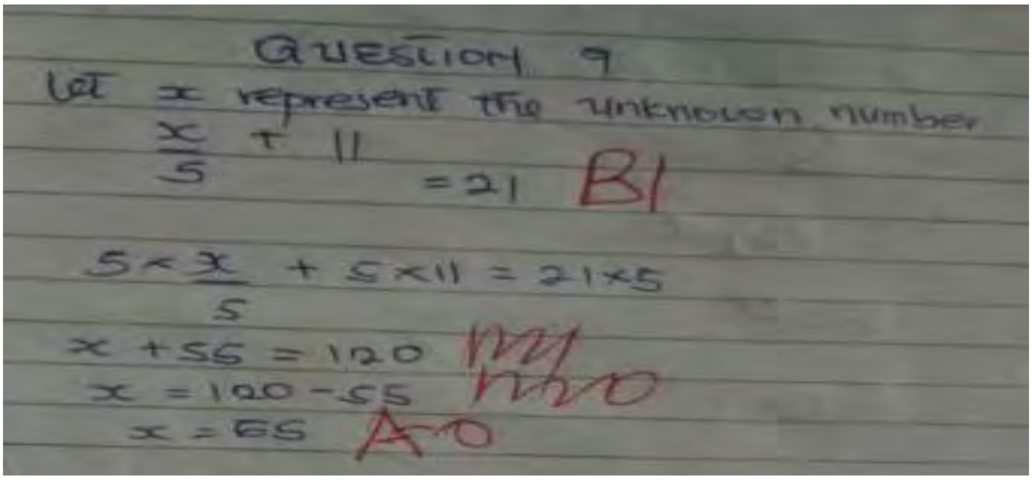

Figure 4.6 Answer showing a computational error by student S6

Application of Inappropriate Mathematical Knowledge

Students sometimes identify the correct operations to solve the problem but do not know the necessary procedures to perform these operations accurately. This happens with 3 out of 21 students who attempted pre-test item number 8. Figure 4.3 shows a student S4 response to pre-test item number 8

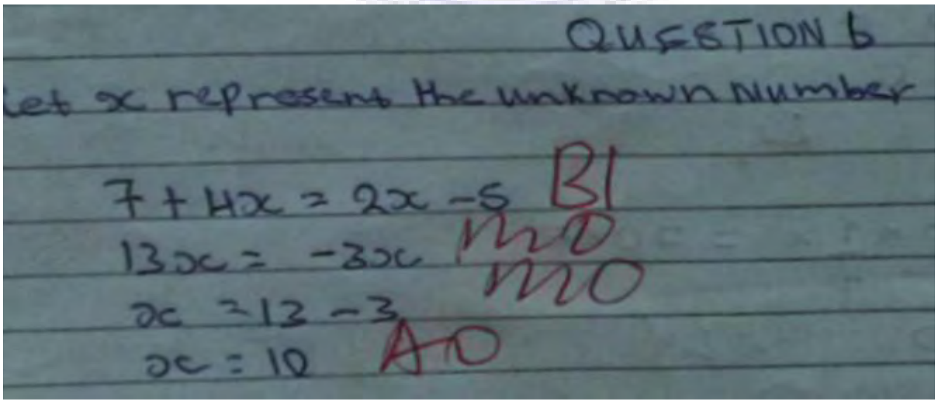

Figure 4.7 Answer showing the application of inappropriate mathematical knowledge.

The solution in Figure 4.7 clearly indicates that the student have difficulties in simplifying algebraic expressions as well as finding solutions to algebraic linear equations.

Student's response to pre-test item number 8

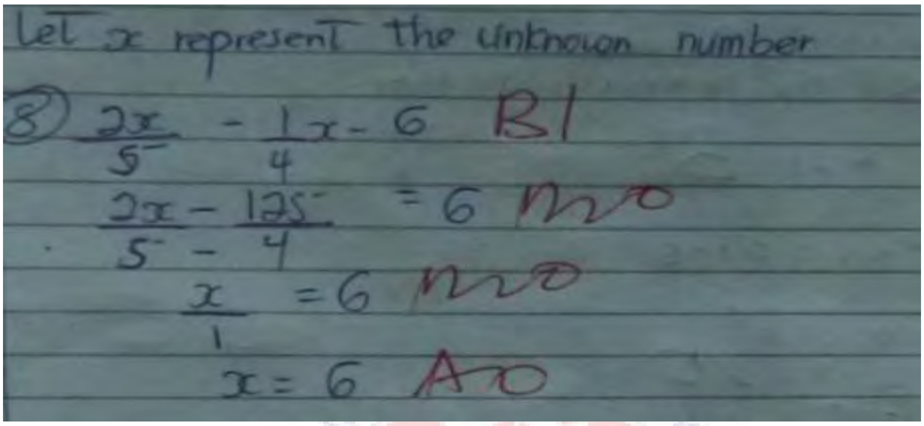

Figure 4.8 Answer showing the application of inappropriate mathematical knowledge

This response revealed the student's inability to add numbers and letters. This suggest that the student lacks the conceptual understanding of grouping like terms, hence, find it difficult to solve the problem correctly. This student also fail to multiply the equation through by the least common multiple (LCM) in order to clear the fractions. This suggest that the student lacks the basic mathematical knowledge needed to solve the equation correctly.

4.2 Research Question 2: What is the effect of traditional teaching approach on students' performances in solving algebraic linear equation word problems?

To answer research question 2, A pre-test was administered the control groups to determine their level of knowledge and skills in translating linear equation word problems into equations and solving the equations as well. After administering the pre-test, the traditional teaching approach was used to teach students in the control group for three weeks. A post-test was then administered after the treatment in order to determine the effect of the traditional teaching strategy. Table 4.4 presents the pre-test and post-test scores of the twenty-two (22) students in the control group. The numbers in brackets under the pre-test and post-test columns are the frequencies with their corresponding percentage (%).

Table 4.4 Frequency Distribution of Pre-Test and Post-Test Scores in Percentages of the Control Group

Scores	Pre-test (Freq.) %	Post-test (Freq.) %
Below average (0-19)	(21) 95%	(5) 23%
Average (20-29)	(1) 5%	(9) 41%
Above average (30-40)	(0)0%	(8) 36%
Total	**(22) 100%**	**(22) 100%**

Source: Field data, 2019

The results in Table 4.4 showed that out of the twenty-two (22) students who wrote the pre-test, 21 representing 95% of the students scored below the minimum average mark of 20. Only one (1) student representing 5% of the students scored a mark between 20 and 29 inclusive and no student had a mark between 30 and 40. The results indicate that, the performance of students in the pre-test was low as 95% of the students scored below the minimum average mark. Excerpts of students' pre-test marked scripts are shown Appendix E.

In order to determine the effect of the traditional teaching strategy on students' performances in solving algebraic linear equation word problems, a pre-test was conducted before the treatment a post-test was administered after teaching the students for three weeks, using traditional teaching approach. The post-test results in Table 4.4 shows that, five (5) students representing 23% scored a marks between 0 and 19. Nine (9) students representing 41% obtained marks between 20 and 29 whilst eight (8) representing 36% of the students scored marks between 30 and 40 inclusive. The post-test results in Table 4.4 indicate that 23% of the students obtained marks below the minimum average mark as compared to 95% in the pre-test. In the pre-test, only one student representing 5% obtained an average mark as compared to 41% in the post-test. Also, no student had a mark within the "above average" in the pre-test compared 36% in the post-test. Comparatively, the results in Table 4.3 showed that students performed better in the post-test than the pre-test. Table 4.5 shows the mean and standard deviation of the paired samples.

Table 4.5 Paired Samples Statistics of Pre-Test and Post-Test Scores for the Control Group

		Mean	N	Std. Deviation
Pair 1	Pretest	7.27	22	5.692
	Posttest	26.41	22	6.486

Source: Field data, 2019

The post-test results in Table 4.5 shows an improvement in students' performance in solving algebraic linear equation word problems. The post-test mean score and standard deviation ($M = 26.41,\ SD = 6.486$) were higher than the pre-test mean score and standard deviation ($M = 7.27, SD = 5.692$). The difference between the post-test and pre-test mean scores is ($26.41 - 7.27 = 19.14$). This improvement of students' performances in the post-test could be attributed to the traditional teaching strategy that was used to teach the students during treatment. This suggest that, the traditional teaching approach has a positive effect on students' understanding and performances in solving algebraic linear equation word problems. This finding implies that a well organised traditional teaching approach can enhance students' understanding and performances in mathematics to some extent. Excerpts of students' post-test marked scripts are shown in Appendix F.

Inferential analysis was carried out using the paired samples t-test to determine if difference observed in students' pre-test and post-test scores is significant.

Table 4.6 presents the paired sample t-test results of pre-test and post-test scores of students in the control group.

Table 4.6 Paired Sample T-Test

					Difference				
		Mean	**Std. Deviation**	**Std. error Mean**	**Lower**	**Upper**	**T**	**DF**	**Sig. (2tailed)**
Pair 1	Pretest - posttest	19.136	7.337	1.564	-22.390	-15.883	12.233	21	0.000

Source: Field data, 2019

A paired samples t-test was conducted to compare the pre-test and post test scores of the students taught using traditional teaching approach. This was done to ascertain the effect of traditional teaching approach on students' performance in solving algebraic linear equation word problems. From Table 4.6, the paired samples t-test analysis of the data resulted in the value of $P = 0.000$, which implied that there is a significant difference between the pre-test and post-test mean scores. The test statistic was set at $P < 0.05$. Since $P < 0.05$ (level of significance), It is therefore concluded that there is a significant difference in performance between the pre-test and post-test scores. This finding implied that a well-structured traditional teaching approach can enhanced students' learning and performance in mathematics.

4.3 Research Question 3: What is the effect of problem solving approach on students' performances in solving algebraic linear equation word problems?

In order to respond to research question 3, a pre-test was conducted to the thirty (30) students in the experimental group to determine their level of performance in solving algebraic linear equation word problems. After administering the pre-test, a problem solving approach was used to teach algebraic linear equation word problems for three weeks. A post-test was conducted after the treatment to determine the effect of the problem solving instructional strategy. Both pre-test and post-test scripts were marked out of 40 marks. Table 4.7 presents the summary of pre-test and post-test scores of students in the experimental group. The numbers in brackets under the pre-test and post-test columns are the frequencies with their corresponding percentages.

Table 4.7 Frequency Distribution of Pre-Test and Post-Test Scores in Percentages of Students in the Experimental Group

Scores	Pre-test	Post-test
Below average (0-19)	(29) 97%	(0) 0%
Average (20-29)	(1) 3%	(9) 30%
Above average (30-40)	(0) 0%	(21) 70%
Total	**(30) 100%**	**(30) 100%**

Source: Field data, 2019

The results in Table 4.7 showed that out of the thirty (30) students who wrote the pre-test, twenty-nine (29) students, representing 97% scored marks between 0 and 19, only one (1) student representing 3% scored a mark between 20 and 30 and no student had a mark between 30 and 40. This indicates that 97% of the students scored below the minimum average score of 20, and only one student representing 3% obtained an average mark. However, the post-test scores showed an improvement compared to the pre-test. In the post-test, no student scored a mark between 1 and 19 as compared 97% in the pre-test. Thirty percent of the students obtained marks between 20 and 29 in the post-test as compared to only 3% in the pre-test. Also, the number of students who scored marks between 30 and 40 showed a remarkable improvement from 0% in the pre-test to 70% in the post-test. This implies that students performed better in the post-test than the pre-test. The higher scores achieved by students in the post-test can be attributed to the problem solving approach that was used to teach the students.

Table 4.8 shows the mean and standard deviation of the paired samples.

Table 4.8 Paired Samples T-Test of Pre-Test and Post-Test Scores of Students in the Experimental Group

		Mean	N	Std. Deviation
Pair 1	pretest	6.90	30	5.248
	posttest	31.43	30	4.939

Source: Field data, 2019

The results in Table 4.8 shows that the mean (M) score and standard deviation (SD) of students in post-test (M = 31.43, SD = 4.939) were significantly higher than the mean score and standard deviation of students in the pre-test (M = 6.90, SD =5.248). The difference in the means between the pre-test and post-test scores is (31.43 - 6.90 = 24.53}. Students learn more when they work as a team. It is worth mentioning that learning in small groups is crucial in every mathematics lesson as students enjoy working together and this builds trust among the students. The performance of students in the post-test can be attributed to the problem solving instructional strategy employed and the series of problem solving activities that the researcher exposed the students to during the treatment processes.

Further inferential analysis was conducted using the paired samples t-test to determine if the difference observed between the pre-test and post-test scores was significant.

A paired samples t-test was conducted to determine the effect problem solving approach on students' performances in solving algebraic linear equation word problems. Table 4.9 presents the t-test results.

Table 4.9 Paired Samples T-Test of the Pre-Test and Post-Test Scores of students in the experimental group

					Difference				
		Mean	**Std. Deviation**	**Std. error Mean**	**Lower**	**Upper**	**T**	**DF**	**Sig. (2 tailed)**
Pair 1	Pretest - posttest	24.533	8.212	1.499	-27.600	-21.467	16.467	29	0.000

Source: Field data, 2019

The paired samples t-test analysis of pre-test and post-test scores in Table 4.9 resulted in the value of $P = 0.000$, which implies that, there is a significant difference in the means of the pre-test and post-test scores. The test statistic was set at $P < 0.05$. Since $P < 0.05$ (level of significance), the study concludes that there is a significant difference between the pre-test and the post-test scores, which is in favour of the post-test. This implies that problem solving approach of teaching had a positive effect on students' performances in solving algebraic linear equation word problems.

4.4 Research Question 4: What are the views of students about the problem solving approach of teaching?

Classroom practices and strategies teachers used are vital to improving students' understanding and problem solving skills in mathematics.

In order to solicit students' views about the use of problem solving approach of teaching linear equation word problems, student in the experimental group (n=30) were given a questionnaire to respond. Students responded to each of the four questionnaire items on a 3-point scale thus, **Agree, Undecided,** and **Disagree**. Table 4.10 presents the frequencies and percentages of students' responses to the questionnaire.

Table 4.10 Frequencies and percentages of responses on views of students on the use of Problem Solving Approach of teaching

Item	Responses Agree Freq. (%)	Undecided Freq. (%)	Disagree Freq. (%)	Total Freq. (%)
1. The use of problem solving approach of teaching in the classroom help me to understand mathematics easily.	24 (80%)	4 (13%)	2 (7%)	30 (100%)
2. The use of problem solving approach in teaching mathematics is time-consuming.	25 (83%)	0 (0%)	5 (17%)	30 (100%)
3. Given students the opportunity to participate actively in mathematics lessons improve their understanding.	21 (70%)	2 (7%)	7 (23%)	30 (100%)
4. The use of learning mathematics in small groups made my learning easier and interesting.	23 (77%)	1 (3%)	6 (20%)	30 (100%)
Total	**90**	**7**	**23**	**120**

Source: Field data, 2019

The results in Table 4.10 shows that 24 (80%) of the students agreed that problem solving approach (PSA) of teaching helps them understand mathematics easily. Only 2 (7%) of the students disagreed with this idea, and 4 (13%) of the students were uncertain as to whether or not problem solving approach of teaching made learning mathematics easier. this results indicate that, majority of the students agreed that teaching mathematics through problem solving approach in the classroom increase their understanding.

Furthermore, 25 (83%) of the students agreed that the use of problem solving approach of teaching in the classroom is time-consuming. However, 5 (17%) of the students disagreed.

Creating an enabling environment for students to participate actively in mathematics lessons is one of the reasons for organizing activities in a problem solving classroom. Twenty-three (77%) of the students agreed that given students the opportunity to participate actively in mathematics lessons improve their understanding, whilst 7 (23%) of the students disagreed to this idea, and 2 (7%) of the students were uncertain as to whether given students the opportunity to participate actively in mathematics lessons improve their understanding.

Again, it can be observed that, 23 (77%) of the students agreed that, learning mathematics in small groups make it easier and interesting. On the other hand, 6 (20%) responses in disagreement, whereas one student was uncertain. The analysis of students' responses to the questionnaire in Table 4.10 indicates that 90 responses agreed on the use of problem solving approach of teaching, 23 responses disagreed, whereas 7 responses were uncertain. This implies that majority of the students in the experimental group do accept that teaching mathematics through problem solving approach enhanced their understanding of mathematical concepts.

The researcher carried out an unstured interview with 6 (six) students in the experimental group. The interviewees consisted of two students who performed well in the post-test; two students who performed averagely, and two students who obtained low scores in the post-test. The interview was meant to complement students' responses to the questionnaire on the use of problem solving approach of teaching and also to show that the results in the post-test was due to the problem solving approach used. Data collected from the interview supported these findings as responses from majority of the respondents indicated in the questionnaire that teaching mathematics through problem solving approach make it easy to learn. The response of students during the interview are shown below:

In the interview, two out of the six interviewees shared the same view that:

> *Problem solving approach made their learning of mathematics easier. They further indicated that they can now translate word problems into equations and solve the equations as well, because they were allowed to work in groups and also discussed the questions among themselves. The discussions takes longer time, but still it is good because it made them understand mathematics better.*

Student A said:

> *'Initially, I thought this teaching method was waste of time but later, I realised that it is good and interesting. It made me understand word problems better'*

Student B is of the view that:

> *'Problem solving method of teaching is good but it is time-consuming. Although I couldn't solve all the quest in the test, I still enjoy the lessons. Sir, continue to use this method in teaching'.*

Student C explained that:

> *'Solving word problems was very difficult for me because there is no formula that I can use to translate the statements in words into equation in order to solve it. But now with the help of problem solving method, I can now solve word problems better'.*

Student D remarked:

> *'I used to think that I was a lower learner but PSA is the best way that is easier, simpler, it is different from the class and we can discuss with other students'.*

Note: The letters A, B, C, and D used for the students are not their real names.

4.5 Null hypothesis H_0: There is no Difference in Performance between Students taught Algebraic Linear Equation Word Problems using Traditional Approach and Problem Solving Approach

To find out whether there is any difference in performance between students taught algebraic linear equation word problems using traditional approach and those taught through problem solving approach, a pre-test comprising ten test items involving algebraic linear equation word problems was administered to students in both control and experimental groups before the treatment, and a post-test after the treatment. Table 4.11 presents the means and standard deviations for pre-test and post-test scores of students in both control and experimental groups.

Table 4.11 Paired Samples T-Test of Pre-Test and Post-Test Scores for the Control and Experimental Groups

Tests	groups	N	Mean	Std. Deviation
pretest	Control	22	7.27	5.692
	Experimental	30	6.90	5.248
posttest	Control	22	26.41	6.486
	Experimental	30	31.43	4.939

Source: Field data, 2019

The results in Table 4.11 shows that, the mean (M) score of the pre-test and standard deviation (SD) of students in the control group (M = 7.27, SD = 5.692) were approximately the same as the mean and standard deviation for the experimental group (M = 6.90, SD = 5.248). This implies that, both groups started with the level of knowledge in terms of solving algebraic linear equation word problems. However, the post-test mean score and standard deviation (M = 31.43, SD = 4.939) of the experimental group were higher than the post-test mean score and standard deviation (M = 26.41, SD = 6.486) of the control group. The difference between the mean scores for the control and experimental groups in the post-test was $(31.43 - 26.41 = 5.02)$. The mean score of the experimental group increased more than that of the control group indicating that students' performance in the experimental group improved more than in the control group.

Further inferential analysis of post-test scores for both control and experimental groups was conducted using the Independent Samples T-test.

Table 4.12 Independent Samples Test of Post-Test Scores for the Control and Experimental Groups

		Levene's Test for Equality of Variances		**T-Test for Equality of Means**						
		SF	**Sig.**	**t**	**df**	**Sig. (2tailed)**	**Mean Dif**	**Std. Error Dif**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Post-test	Equal variances assumed	1.451	.234	-3.173	50	.003	-5.024	1.583	-8.204	-1.844
	Equal variances not assumed			-3.044	87.719	.004	-5.024	1.651	-8.367	-1,682

Source: Field data, 2019

An independent samples t-test was conducted to verify if there is a significant difference in performance between the control and experimental groups in the post-test. The analysis of the post-test scores in Table 4.12 resulted p = .003, which is less than .05 level of significance. This implies that there is a significant difference in the mean scores between the control and experimental groups. The results in Table 4.12 show that, the experimental group was more successful than the control group after the treatment. Hence, the null hypothesis that "there is no significant difference in performance between students taught algebraic linear equation word problems using traditional approach and problem solving approach" was rejected. This study therefore concludes that students taught algebraic linear equation word problems through problem solving approach performed better than their peers who were taught using the traditional teaching method. The difference in performance may be due the fact that traditional teaching approach does not usually permit students to become actively engaged and express their opinions in the teaching and learning process. Consequently, problem solving approach of teaching could be viewed as a superior instructional strategy that could benefit senior high school students in Ghana, if well implemented.

4.6 Major Findings

The analysis of the pre-test marked scripts of the students revealed four major difficulties. These are: (1) Lack of understanding of the problem; (2) Misinterpretation of the problem; (3) Computational Errors; (4) Application of Inappropriate Mathematical Knowledge. The study also revealed that the traditional approach of teaching is capable of improving students' performances to some extent. The study further revealed that problem solving approach helped improved students' understanding and performance in mathematics. Again, this study found that problem solving approach used in teaching mathematics to senior high school students has the potential of fostering understanding mathematics concepts hence, improve their performance in mathematics. Also, this study compared the effectiveness of traditional teaching and problem solving approaches. Analysis of the pre-test scores indicate that students in both control experimental groups had the same entry level before the treatment. However, analysis of the post-test scores indicate that students taught through problem solving approach achieved more academic gains than those taught using the traditional teaching strategy. This indicates that Mathematics concepts and procedural skills learnt through the traditional teaching approach were not clearly understood by the students. Students were not able to apply the knowledge acquired to solve the word problems. Hence the study concludes that problem solving approach of teaching is more effective than the traditional teaching method in terms improving students' academic performances. The study also examined the views of students about the use of problem solving instructional strategy in the classroom. A questionnaire was distributed to the students in the experimental group an oral interview was conducted with the experimental group after administering the post-test. The analysis of their responses revealed that majority of the students agreed that problem solving approach of teaching is time-consuming but felt that it is good. It created opportunity for them to address students' difficulties regarding solving algebraic linear equation word problems. Students felt that problem solving approach made word problem lessons interesting, interactive and easier.

4.7 Discussion of Findings

Students' success in Mathematics is greatly influenced by the instructional strategy employed by their teacher. Effective teaching method may enhance students' understanding and performances in Mathematics. Students who receive high-quality teaching in Mathematics experience greater and more persistent achievement gains than their counterpart who receive lower-quality teaching in Mathematics (Rivkin et al., 2005). This study was an attempt to contribute to the present search for effective teaching approaches that will enhance students' understanding, and develop their problem solving skills in Mathematics. Hence, the current study investigates the effect of problem solving approach of teaching on senior high school students' performances in solving algebraic linear equation word problems.

The knowledge of difficulties students faced in the process of solving algebraic linear equation word problems help teachers plan their lessons better. In order to obtain these difficulties, a pre-test was conducted to control and experimental groups. Studies such as Sepeng et al., 2014) indicated that the most difficult part of solving mathematics word problems appear to be the process of comprehending the problem statement and deciding on the appropriate operation(s) need(s) to solve the problem. The analysis of the pre-test marked scripts revealed four major difficulties. These are: (1) Lack of understanding of the problem; (2) Misinterpretation of the problem; (3) Computational Errors; (4) Application of Inappropriate Mathematical Knowledge. The findings of this study are consistent with those obtained by Yeo (2009). For instance, Yeo (2009) found that the major difficulties students faced when solving word problems involves translating the statements in words into correct equations and solving the resulting equations as well. Most of the students encountered difficulties in translating the word problems into appropriate equations as they were unable to visualize and did not understand the problem at all. Some students also misinterpreted the problem statement, hence, modeled wrong equations out of the text. The results of this study are in line with the findings of Aniano (2010) who observed that, students' inability to translate verbal descriptions into mathematical symbols and operations is one of the contributing factors that hinder their problem solving capabilities. Studies such as Egodawatte (2011) have noted that, challenges students faced during word problems solving usually entail students' inability to translate the problem into equation and failure to use the correct representations. The vocabulary aspect of the problem is very difficult for many students to comprehend. Sometimes, students do not understand the meaning of specific words in the problem statement and this hinder their progress in solving the problem. This finding of the study agrees with earlier findings in the research of Adu (2013) who found that students made errors in the process of translating word problems into expressions or equation because they did not comprehend the problem. Bishop et al., (2008) also noted that the main source of students' difficulties encounter in solving word problems entail how to translate the statements in words into appropriate equations. This was supported by Sepeng (2013) who argued that solving word problems is difficult for many students because of the unrealistic strategies that students adopt in solving these problems. Sepeng further noted that for students to successfully solve word problems, they should know how to use text to identify missing information, construct number sentences and set up a calculation strategy for finding the missing information. The analysis of students pre-test marked scripts revealed that lack of mathematical skills and understanding of word problem statement were the major difficulties students' encounter in the process of solving word problems. The findings of this study are similar the findings obtained by Lumpkin et al., (2007). For instance, Lumpkin et al., (2007) found that the poor problem solving abilities exhibited by students during word problem solving is due to an error in one of the three places along the problem solving process: an incorrect interpretation of the problem or inability to comprehend the problem, flaws in the setup of the problem, and/or errors in computation.

In search for effective teaching approach that will address students' difficulties in solving algebraic linear equation word problems, the traditional teaching and problem solving approaches were investigated. In order to ascertain and compare the effectiveness of the traditional teaching and problem solving approaches, a pre-test was conducted to both control and experimental groups before the commencement of the treatment, and a post-test after the treatment. The results in Table 4.11 showed that, the pre-test mean scores and standard deviation (M = 7.27, SD = 5.692) and (M = 6.90, SD = 5.248) for the control and experimental groups respectively are similar. This indicate that there was no significant difference in the mean scores and standard deviations of students in the control and experimental groups in the pre-test suggesting that students in both control experimental groups had the same entry level prior to the commencement of the treatment. However, the analysis of the post-test scores in Table 4.9 indicates that the mean scores and standard deviations (M = 26.41, SD = 6.486) and (M = 31.43, SD = 4.939) for the control and experimental groups respectively were significantly higher than their respective pre-test mean scores and standard deviations. This indicate that students in both control and experimental groups performed better in post-test than the pre-test. However, the post-test results in Table 4.11 showed that the mean score of students in the experimental group is higher than the mean score of the control group suggesting that the students taught with problem solving approach achieved higher scores than those taught with the traditional teaching approach. The significant improvement observed in the post-test by the experimental group attest to the argument that a problem solving approach has the potential of fostering students learning and therefore improving their performance in mathematics (Van De Walle, 2004). The post-test results again demonstrated that students' in control group could not apply knowledge gain in mathematics to solve word problems. This implies that the traditional teaching approach used in teaching students in the control group did not help the students adequately enough to enable them apply the knowledge and skills acquired to solve word problems that require the use of critical thinking to solve them. Further analysis was conducted using the independent samples t-test to determine whether the difference observed in the post-test scores between the control and experimental groups is significant. The analysis of the data in Table 4.12 resulted p = .003, which less than 0.05 level of significance. This implies that the difference in performance between students taught algebraic linear equation word problems using problem solving approach and those taught with the traditional teaching method is significant. Students taught using problem solving strategy achieved significantly higher gains than those taught with the traditional method. Achievement is the product of mastery of concept. Students in experimental group achieved higher gains than their peers in the control group because they had mastery of the concept taught as a result of the problem solving teaching strategy used to teach them. The findings of the present study implies that problem solving approach of teaching is more effective than the traditional teaching method. Similar observations have also been stated by Mwelese et al. (2014) while studying the effectiveness of problem solving teaching strategy. Mwelese et al. (2014) maintained that the traditional teaching approach does not encourage students' active participation and peer interactions in the teaching and learning process. Hence, have limited effectiveness in improving understanding and academic performance of students. The higher achievement gains obtained by the experimental group in the post-test could be attributed to the problem solving teaching strategy used in teaching them. In problem solving instruction, students were given the opportunity to participate actively in the teaching and learning processes. Cooperative learning is a key instructional strategy when implementing a problem solving approach of teaching. In cooperative learning, each student in a group was not only responsible for learning what was being taught alone, but also helps other members who were still having challenges. Franke et al. (2007) argued that students learn better within a social setting in which understanding is co-constructed with others. The improvement in the performance of the students in the experimental group could be attributed to the problem solving teaching strategy in which students were allowed to participate actively in the teaching and learning processes. The findings of this study supports the findings of Kousar (2010) who concluded that, problem solving approach of teaching is more effective than the traditional teaching method in improving students' academic performances. Kousar (2010) observed that there was active participation of students in performing activities and interaction among themselves in the problem solving instruction. Students who experienced problem solving activities showed higher level of understanding and retention of mathematics concepts with high confidence level than students in the traditional teaching group. The results of this study are in line with observation made by Wang and Posey (2011) that the traditional approach of teaching mathematics do not seem to help students achieve the intended learning goals in the curriculum. The current findings implies that, adopting a problem solving approach of teaching in the Ghanaian classrooms could be a possible solution to the poor performance of students in mathematics.

The views of students on the type of teaching approach employed by their teacher plays an important role in their attitudes, anxiety and performance in mathematics (Yager, 1991). In order to examine the views of students about the use of problem solving approach of teaching, a questionnaire was distributed to the students in the experimental group an oral interview was conducted with the experimental group after administering the post-test. The analysis of their responses revealed that majority of the students (83%) found the problem solving approach time-consuming but later felt that it created opportunity for them to address individual learning weakness regarding solving algebraic linear equation word problems. It was then concluded that the problem solving approach was more favorable than traditional teaching approach in enhancing understanding and performance of students in mathematics. Students felt that problem solving approach made word problem lessons interesting, interactive and easier. Problem solving techniques motivated the students, as a result, they endorsed problem solving of teaching in the classroom. This can be inferred from students' response to the questionnaire and the interview. The current study provides evidence that problem solving approach of teaching creates active learning environment which is more effective than traditional method for promoting academic achievement, enhancing conceptual understanding, and higher order thinking skills and developing a more positive attitude towards learning mathematics.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter summaries the findings of the study, conclusion, recommendations and provide suggestions for further studies.

5.1 Summary of the Study

Students understanding of mathematical concepts and performance depends largely on good instructional approaches adopted by their teachers. This study therefore investigated the effect of a problem solving approach on senior high school students' performances in solving algebraic linear equation word problems. A quasi-experimental non-equivalent pre-test and post-test control group research design was employed in the study. In order to identify the challenges students' encounter when solving algebraic linear equation word problems, a pre-test consisting of ten (10) test items involving algebraic linear equations was administered to students. Analysis of the pre-test marked scripts revealed students' difficulties in solving algebraic linear equation word problems. In particular, students do not comprehend the sentences in word problems as they found the problems confusing. Hence, translating the word problems into equations became difficult In order to ascertain the effect of a problem solving approach on students' performances in solving algebraic linear equation word problems, control and experimental groups were formed. The experimental was taught with the problem solving approach whiles the control group was taught using the traditional teaching method. Both control and experimental groups were taught the same concept/topic for three weeks. A pre-test was administered to both groups before the commencement of the treatment and a post-test was conducted at the end of the treatment to determine the comparative effects of the two teaching approaches. Analysis of the scores obtained from pre-test and post-test indicated that both control and experimental groups started with the same level of knowledge in terms of solving algebraic linear equation word problems. The analysis of the post-test scores showed that both groups performed better in the post-test than the pre-test. However, the experimental group was more successful than the control group. The major findings from this study are:

1. Students' difficulties in solving word problems were found to be translational problems, misinterpretation, inability of students to apply appropriate mathematical knowledge and computational errors.
2. Students in both control and experimental groups performed better in the post-test than the pre-test. However, students taught using problem solving approach had higher achievement scores than those taught with the traditional teaching strategy.
3. The traditional teaching approach is also capable of improving students' performances in mathematics to some extent.
4. The students also felt that problem solving approach of teaching is good. It helped them understand mathematics better by allowing them to discuss the problems with one other.

5. 2 Conclusion

Problem solving approach of teaching is a student-centered teaching strategy that engages students actively in the learning process, enhances their understanding of mathematics concepts and develops their problem solving skills. Teaching mathematics through a problem solving approach provides a learning environment for students to learn on their own, to explore problems and to find new ways to solve the problems. This study investigated the effect of a problem solving approach of teaching on students' performances in solving algebraic linear equation word problems at two senior high schools in the Kwaebibirem municipality in the Eastern Region of Ghana. Two teaching strategies were used thus, problem solving approach and the traditional teaching strategy. Analysis of students' pre-test and post-test scores indicate that, entry behaviours for both control and experimental groups were similar. However, students in the experimental group performed better than the control group in the post-test. This implies that problem solving strategy has helped to improve students' competences in solving algebraic linear equation word problems. Problem solving approach allows students to build on their translational competencies, representational skills and computational powers thereby optimizing their performance in solving word problem. The study therefore concludes that a problem solving approach if well implemented has the potential of increasing students' performance in mathematics.

5.3 Recommendations

Based on the findings of this study, the following recommendations were made:

1. Students' success in Mathematics is greatly influenced by the teaching strategy employed by their teacher. Effective teaching method may enhance students' understanding and performances in Mathematics. Students who receive high-quality teaching in Mathematics experience greater and more persistent achievement gains than those who receive lower-quality teaching in Mathematics. Therefore, Mathematics teachers at the senior high school level should try as much as possible to adopt problem solving approach of teaching

in their lessons in order to provide conducive learning environment and encourage students' active participation in the teaching and learning process for better understanding and performance in mathematics.

2. Ghana Education Service (GES) should organise regular In-service training workshops on problem solving approach of teaching to all mathematics teachers at the Senior High School level.
3. Curriculum Research and Development Division (CRDD) in collaboration with the Ghana Education Service (GES) should provide mathematics textbooks that contains more practical problems that students can practice in order to improve their problem solving skills in mathematics.
4. A teacher's experience of learning mathematics has an impact on his/her teaching approach. The study recommends that teacher training institutions in Ghana should train mathematics teachers with Problem Solving Method to qualify them as professional teachers.
5. The study recommends that Ministry of Education (MoE) in collaboration with the Ghana Education Service (GES) should introduce a comprehensive programme in the form of an implementation model lasting for at least a period of three years to promote full compliance and implementation of a problem-solving approach of teaching by all mathematics teachers at the senior high school level in Ghana so as to ensure greater and more persistent achievements of students in mathematics.

5.4 Suggestions for Further Studies

It is suggested that in future, a study like this should be extended to more schools and increase the population and sample size as well. This research can be replicated by other researchers to find the effect of problem solving approach of teaching on other topics in mathematics. It is also suggested that future studies should focus on the long-term effects of problem solving approach of teaching on students' understanding and performances in mathematics. This can be done by extending the duration for the treatment and follow up with performance of both the control and experimental groups for at least two years.

REFERENCES

Adu E. (2013). *Swedru School of Business students' difficulties in solving linear equation word problems.* (Unpubished BSc project report), Winneba. University of Education, Winneba, Department of Mathematics.

Adu E., Mereku D. K., Assuah K. C., & Okpoti A. C. (2017). Effect of multimedia courseware with cooperative learning on senior high school students' proficiency in solving linear equation word problems. *African Journal of Educational Studies in Mathematics and Sciences Vol. 13.*

Akyeampong, K., Lussier, K., Pryor, J., & Westbrook, J. (2013). Improving teaching and learning of basic mathematics and reading in Africa: Does teacher preparation count? *International Journal of Educational Development*, 272-282.

Ali, R., Hukam D., Akhter, A., & Khan, A. (2010). Effect of using problem solving method in teaching mathematics on the achievement of mathematics students. *Asian Social Science, 6*, 67-72. Retrieved from: www.ccsenet.org/ass.

Alleviato, N. S. G., & Onuchic, L. R. (2007). *Teaching mathematics in the classroom through problem solving.* Retrieved from http:// tsg. icme 11.org/ document/ get/453.

Ampadu, E. (2012). *An investigation into the teaching and learning of mathematics in junior high schools: The case of Ghana*. Unpublished Doctoral dissertation, Anglia Ruskin University, UK.

Anderson, C. R. (2007). Examining school mathematics through the lenses of learning and equity. In W. G. Martin & M. E. Strutchens (Eds.), *The Learning of Mathematics* (pp. 97-112). Reston, VA: National Council of Teachers of Mathematics.

Anderson, J., Sullivan, P., & White, P. (2004). The influence of perceived constraints on teachers' problem-solving beliefs and practices. In I. Putt, R. Faragher, & M. McLean (Eds.), Mathematics education for the third millennium: Towards 2010 (pp.39-46). Proceedings of the 27th annual conference of the Mathematics Education Research Group of Australasia, Townsville, Queensland.

Aniano, L. C. (2010). Difficulties in solving word problems on fractions among grade vi pupils of Balara Elementary School. Morong, Rizal: *Unpublished master thesis*. University of rizal.

Annum, G. (2017). *Research instruments for data collection*. Retrieved on 27th February,2018, from http://campus.educadium.com/newmediart/file.php/137/Thesis_Repository/recds/assets/TWs/UgradResearch/ThesisWrit4all/files/notes/resInstr.pdf

Barkley, E. F., Cross, K. P., & Major, C. H. (2005). *Collaborative Learning Techniques: A Handbook for College Faculty.* San Francisco: Jossey-Bass.

Barwell, R. (2011, June). *Word Problems Connecting language, mathematics and life.*Retrieved from Ontario Ministry of Eduaction: https://www.edu.gov.on.ca /eng/literacynumeracy/inspire/research/WW_Word_Proble ms.pdf

Bassey, S. W., Joshua, M. T., & Asim, A. E. (2011). Gender Differences and Mathematics Achievement of Rural Senior. Mathematics Connection, 1-8.

Bello A. S. (2014). Influence of Enrichment Package on Mathematics Achievement, Retention and Anxiety among JSS Student in Adamawa State Nigeria; *Unpublished Ph.D Dissertation ABU, Zaria.*

Best, J. W., & Kahn, J. V. (2007). *Research in Education.* New Delhi, Printice Hall of India.

Bishop, A., Filloy, E., & Puig, L. (2008). *Educational algebra: A theoretical and empirical approach*. Boston, MA, USA: Springer.

Boaler, J. (2008). When politics took the place of inquiry: A response to the National Mathematics Advisory Panel's report of instructional practices. *Educational Researcher, 3,* 588-594.

Boaler, J., & Staples, M. (2008). Creating Mathematics futures through an equitable teaching approach: The case of Railside School. *Teachers College Record, 110*, 608-645.

Booth, L. R. (1984). Algebra: children's strategies and errors. A report of the strategies and errors in secondary Mathematics project. Windsor, United Kingdom: NFER-NELSON.

Bostic, J., & Pape, S. (2010). Examining Students' Perceptions of Two Graphing Technologies and Their Impact on Problem Solving. *Journal of Computers in Mathematics and Science Teaching, 29,* 139-154.

Bruner, J. (1985). Vygotsky: An historical and conceptual perspective. In J. V. Wertsch (Ed.), *Culture, communication, and cognition: Vygotskian perspectives* (pp. 21-34). Cambridge: Cambridge University Press.

Burton, M. B. (1991). Grammatical translation inhibitors in two classic word problem sentences. For the Learning of Mathematics. 11(1):43-46.

Cai, J. (2010). Commentary on Problem Solving Heuristics, Affect, and Discrete Mathematics: A Representational Discussion. In B. Sriraman, & L. English (Eds.), Theories of Mathematics Education: Seeking New Frontiers (pp. 251-258). Dordrecht: Springer. https://doi.org/10.1007/978-3-642-00742-2_25.

Calabrese, R. (2006). The Elements of an Effective Dissertation and Thesis: A Step-by-Step Guide to Getting it Right the First Time. Lanham, MD: Rowman & Littlefield Education, Inc.

Chamot, A. U., & O'Malley, J. M. (1994). *The CALLA handbook: Implementing the cognitive academic language learning approach.* MA: Addison-Wesley Publishing Company.

Charles, R., Lester, F., & O'Daffer, P. (1987). *How to evaluate progress in problem solving*.NCTM, Inc, Reston.

Charles-Ogan, G. I., & Otikor, M. S. (2016). Practical utility of mathematics concepts among senior secondary school students in rivers state. *European Journal of Mathematics and Computer Science*, *3* (1), 2059-9951.

Clement, D. H. (2013). *Instructional Practices and Student Math Achievement: Correlations from a study of math curricula***.** University of Denver Morgridge College of Education.

Cobb, P., Wood, T., & Yackel, E. (1991). 'A constructivist approach to second grade mathematics'. In von Glaserfield, E. (Ed.), Radical Constructivism in Mathematics Education, pp. 157-176. Dordrecht. The Netherlands: Kluwer Academic Publishers.

Cohen, L., Manion, L., & Morrison, K. (2004). *Research methods in education* (5th ed.). London: Routledge Falmer.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. Seventh Edition. Routledge Falmer.

Cook, T. D. (2002). *Randomized experiments in education: Why are they so rare?* North-western University, USA: Institute for Policy Research Working Paper.

D'Ambrosio, B. S. (2003). Teaching mathematics through problem solving: A historical perspective. In H. L. Shoen (Ed.), *Teaching mathematics through problem solving, Grades 6-12* (pp. 39-52). Reston, VA: National Council of Teachers of Mathematics.

Davies, P. J., & Hersh, R. (2012). The Mathematical Experience. Boston: Mifflin Company. Retrieved from http://cut-the-knot.org

Dela-Cruz, J. K., & Lapinid, M. R. (2014). *Students' Difficulties in Translating Worded Problems into Mathematical Symbols.* Retrieved from De La Salle University: http://www.dlsu.edu.ph/conferences/dlsu_research_congress/2014/_pdf/proceedings/LLI-I-009-FT.pdf.

Depaepe, F., De Corte, E., & Verschaffel, L. (2010). Teachers' Approaches towards Word Problem Solving: Elaborating or Restricting the Problem Context. Teaching And Teacher Education: *An International Journal Of Research And Studies*, 26, 152-160.

Dhlamini, J. J. (2012). *Investigating the effect of implementing a context-based problem solving instruction on learners' performance*. PhD Thesis, University of South Africa, South Africa.

Dillman, D. A. (2000). *Mail and internet surveys: the tailored design method*. New York: John Wiley & Sons, Inc.

Egodawatte, G. (2011). *Secondary school students' misconceptions in algebra.* (Doctoral Dissertation), University of Toronto, Canada. ProQuest Dissertations and Theses database. (NR77791).

English, L., Lesh, R., & Fennewald, T. (2008). *Future directions and perspectives for problem solving research and curriculum development*. Paper presented at ICME 11, Topic Study Group 19 – Research and development in problem solving in mathematics education. Monterrey, Mexico.

Ernest, P. (1996). Varieties of constructivism: A framework for comparison. In L. P. Steffe, P. Nesher, P. Cobb, G. A. Goldin, & B. Greer (Eds.), *Theories of mathematical learning* (pp. 389-398). Hillsdale, NJ: Erlbaum.

Evan, R., & Lappin, G. (1994). 'Constructing meaningful understanding of mathematics content', in Aichele, D. and Coxford, A. (Eds.) Professional Development for Teachers of Mathematics , pp. 128-143. Reston, Virginia: NCTM.

Fajemidagba, O. (1986). Mathematical word problem solving: An analysis of error committed by students. *The Nigerian Journal of Guidance and Counselling, 2*(1), 23-30.

Filloy, E., Rojano,T., & Puig, L. (2008). *Educational algebra. A theoretical and empirical approach*. New York: Springer.

Fisher, K. J., Borchert, K., & Bassok, M. (2011). Following the standard form: Effects of equation format on algebraic modeling. *Memory and Cognition*, *39*, 502-515. doi: 10.3758/s13421-010-0031-6.

Fox, N. (2009). *Using interviews in a research project.* Retrieved from https://www.rds- yh.nihr.ac.uk/wp-content/uploads/2013/05/15_Using-Interviews-2009.pdf.

Franke, M. L., Kazemi, E., & Battey, D. (2007). *Understanding teaching and classroom practice in mathematics. In F. K. Lester (Ed.), Second handbook of research on mathematics teaching and learning*. Charlotte, USA: Information Age Pub.

Gay, L. R., Mills, E., & Airasian, P. (2011). Educational Research: *Competencies for analysis and application.* (Tenth Edition). Upper Saddle River. NJ: Pearson Education.

Gay, L. R., Mills, G., & Airasian, P. W. (2009). *Educational research: Competencies for analysis and applications* (9th ed.). Upper Saddle River, New Jersey: Merrill Prentice Hall.

Gllies, R. (2002). The residual effects of cooperative learning experiences: A two year follow-up. *The Journal of Educational Research, 96*, 1, 15-20.

Griffin, C. C., & Jitendra, A. K. (2009). Word problem-solving instruction in inclusive third-grade mathematics classrooms. *Journal of Education Research, 102*(3), 187-202.

Hegarty, M., Mayer, R. E., & Green, C. E. (1995). Comprehension of arithmetic word problems: Evidence from students' eye fixations. *Journal of Educational Psychology, 84*(1), 76-84.

Hiebert, J., & Wearne D. (1993). Instructional task, classroom discourse, and learners' learning in second grade arithmetic. *American Educational Research Journal, 30,* 393-425.

Ilany, B. S., & Margolin, B. (2010). Language and mathematics: Bridging the gap between natural language and mathematical language in solving problems in mathematics. *Creative Education*, *1*(3), 138-148.

Jerry E. W. (2014). *An Investigation of Factors Affecting Student Performance in Algebraic Word Problem Solutions*. PhD Dissertation. Gardner-Webb University.

Kersaint, G., Thompson, D. R., & Petkova, M. (2009). Teaching Mathematics to English language learners.New York: Rutledge.

Knuth, E. J., Alibali, M. W., Mcneil, N. M., Weinberg, A., & Stephens, A. C. (2005). Middle school students understanding of core algebraic concepts: equivalence and variable. *ZDM, 37*(1), 68-76.

Kousar, P. (2010). Effect of the problem-solving approach on academic achievement of learners in Mathematics at the secondary level. *Contemporary Issues in Education Research,* 3(3), 9.*language learners*. New York: Routledge.

Krulik, S., & Posamentier, A. (1998). *Problem Solving Strategies for Effcient and Elegant Solutions.* Corwin Press Inc.

Krulik, S., & Rudnick, A. (1987). *A handbook for teachers' second edition.* Ally and Bacon Inc.

Lai, E. R. (2011). Collaboration: *A literature review. Research report.* New York, NY: Pearson.

Lai, Y., Zhu, X., Chen, Y., & Li, Y. (2015). Effects of Mathematics Anxiety and Mathematical Metacognition on Word Problem Solving in Children with and without Mathematical Learning Difficulties. *Plos ONE*, *10*(6), 1-19. doi:10.1371/journal.pone.0130570

Lester, F. K. Jr., Masingila, J. O., Mau, S. T., Lambdin, D. V., dos Santon, V. M., & Raymond, A. M. (1994). Learning how to teach via problem solving In D. Aichele, & A. Coxford (Eds.), *Professional development for teachers of mathematics* (pp. 152-166). Reston, Virginia: NCTM.

Lumpkin, A. R., & McCoy, L. P. (2007). *The problem with word problems*. Unpublished manuscript, Department of Education, Wake Forest University, Winston-Salem, NC.

Ma, L. (1999). *Knowing and teaching elementary Mathematics: Teachers' understanding of fundamental Mathematics in China and the United States*. New York, NY: Routledge Taylor and Francis Group.

Marshall, S. P. (1995). *Schemas in problem solving. New York, NY:* Cambridge University Press.

Masingila, J. O., & Prus-Wisniowska, E. (1996). Developing and assessing mathematical understanding in calculus through writing. In P. C. Elliot & M. J. Kenney (Eds.), *Communication in mathematics k-12 and beyond* (pp. 95-104). Reston, VA: National Council of Teachers of Mathematics, Inc.

Masingila, J. O., Lester, F., & Raymond, A. M. (2011). Mathematics for elementary teachers via problem solving: Instructor manual. Ann Arbor, MI: Xan Edu Publishing Inc.

Mayer, R., & Wittrock, M. (2006). Problem solving. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (pp. 287-303). Mahwah, NJ: Erlbaum.

Mercer, N., & Littleton, K. (2007). Commentary on the Reconciliation of Cognitive and Sociocultural Accounts of Conceptual Change**.** *Educational Psychologist, 42*(1), 75-78.

Mereku, D. K. (2010). Five decades of school mathematics in Ghana. Mathematics Connections, 9(8), 73-86.

Mereku, D. K., & Cofie, P. O. (2008). Overcoming Language Difficulties in Solving Mathematics Problems in Basic Schools in Ghana. *Mathematics connection, 7(7), 77-89*. Mathematics Association of Ghana.

Ministry of Education Youth and Sports (2010). *Teaching Syllabus for Mathematics (Senior High School).* Accra, Ghana: Ministry of Education, Youth and Sports.

Montague, M. (2003). Solve it. *A practical approach to teaching mathematical problem-solving skills*. Reston, VA: Exceptional Innovations.

Mtitu, E. A. (2014). *Learner-centred teaching in Tanzania: Geography teachers' perceptions and experiences*. Victoria University of Wellington.

Mullis, I. V. S. Martin, M. O. Foy, P., & Arora, A. (2012). TIMSS and PIRLS 2011: *Relationships Among Reading, Mathematics, And Science Achievement-Implications For Early Learning.* Retrieved on November 24, 2018, from http://timss.bc.edu/ timsspirls2011/ downloads/TP11_Intro.pdf,

Mullis, I. V. S., Martin, M. O., & Foy, P. (2008). TIMSS 2007 International Mathematics Report: *Findings from IEA's International Trends in Mathematics and Science Study at Fourth and Eighth Grades.* TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

Mwelese J. K., & Wanjala M. S. (2014). Effect of Problem Solving Strategy on Secondary School Students Achievement In Circle Geometry In Emuhaya District of Vihiga County; *Journal of Education Arts and Humanities.* Department of Science and Mathematics Education Masude Muliro University of Science and Technology. Mase No Kenya: *Vol 2(2),* pp18-26.

Nafees, M. (2011). *An experimental study on the effectiveness of problem-based versus lecture-based instructional strategy on achievement, retention and problem solving capabilities in secondary school general science students.* PhD unpublished thesis, International Islamic University, Islamabad.

National Council of Teachers of Mathematics (2009). *Focus in high school mathematics: Reasoning and sense making.* Reston, VA: Author.

National Council of Teachers of Mathematics (2014). *Principles to actions: Ensuring mathematical success for all.* Reston, VA.

National Council of Teachers of Mathematics (2018). *Catalyzing change in high school mathematics: Initiating critical conversations.* Reston, VA: Author.

Ngussa, B. M. & Makewa, L. N. (2014). Constructivism experiences in teaching-learning transaction among Adventist Secondary Schools in South Nyanza, Tanzania. *American Journal of Educational Research*, 2 (11A), 1-7.

North, L. (1992). *T2-TV supplemental materials, scientific literacy*. Illinois council of teachers of mathematics.

Olowa, O. W. (2009). *Effects of the Problem Solving and Subject Matter Approaches on the Problem Solving Ability of Secondary School Agricultural Education*, Journal of Industrial Teacher Education, v46 n1 p33-47.

Osuala, E. C. (2001). *Introduction to Research Methodology*. Nsuka: Rex Printing Ltd.

Oviedo, G. C. (2005). Comprehending Algebra Word Problems in the First and Second Languages. In J. Cohen, McAlister, K. Rolstad and J Mac Swan (Eds) ISB4.

Oyarole Y.A. (2012) Effects of Problem Solving Strategy on students Academic Achievement and Retention in Ecological Concepts among SSS in Zaria Educational Zone, Kaduna State Nigeria.

Pai, H. H. (2012). Effects of cooperative versus individual study on learning and motivation after reward-removal. *The Journal of Experimental Education*, *80*(3), 246-262.

Pape, S. (2004). Middle school children's problem-solving behavior: A cognitive analysis from a reading comprehension perspective. *Journal for Research in Mathematics Education, 35*, 187-219.

Pearce, D. L., Bruun, F., Skinner, K. & Lopez-Mohler, C. (2013). What Teachers Say About Student Difficulties Solving Mathematical Word Problems in Grades 2-5. *International Electronic Journal of Mathematics Education*, *8*(1), 3-19.

Pfannenstiel, K., Bryant, D., Bryant, B., & Porterfield, J. (2015). *Cognitive Strategy Instruction for Teaching Word Problems to Primary-Level Struggling Students.* Retrieved from SAGE journals: http://isc.sagepub.com /content/50/5/291 .full.pdf+ html

Piaget, J. (1970). *Genetic epistemology*. New York: Columbia University Press.

Polit, D. F., & Beck, C. T. (2012). *Nursing research: Generating and assessing evidence for nursing practices*. Philadelphia: Wolters Kluwer Health/Lippincott William & Wilkins.

Polya, G. (1945). *How to solve it: A new aspect of mathematical method* Princeton, New Jersey: Princeton University Press.

Portal, J., & Sampson, L. (2001). *Improving high school students' mathematics achievement through the use of motivationnal strategies*. Chicago, Saint Xavier University. (ERIC Document Reproduction Service No. ED460854).

Reed, S. K. (1999). *Word problems: Research and curriculum reform.* Mahwah, NJ: Lawrence Erlbaum Associates.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. Econometrica, 73(2), 417–458.

Robson, C. (2011). *Real World Research: A Resource for Users of Social Research Methods in Applied Settings*, (2nd Ed.). Sussex, A. John Wiley and Sons Ltd.

Rosales, J., Santiago, V., Chamoso, J. M., Munez, D. & Orrantia, J. (2012). Teacher-student interaction in joint word problem solving. *The role of situational and mathematical knowledge in mainstream classrooms. Teaching and Teacher Education*, 28(8), 1185-1195.

Schoenfeld A. H. (1983). The wild, wild, wild, wild, wild world of problem solving: A review of sorts, For the Learning of Mathematics, 3, 40-47.

Schoenfeld, A. H. (2011). *How we think: A theory of human decision-making with educational applications*. New York: Routledge.

Schoenfeld, A. H. (2013). Reflections on Problem Solving Theory and Practice. Time, 10(1&2), 9. Retrieved November 30, 2018 from http://www.math.umt.edu/tmme /vol10no1and2/1- Schoenfeld_pp9_34.pdf.

Seidu, A. (2015). Writing a Theses: *A guide for social science students*. Accra: Supreme Concept.

Sepeng, P. (2013). Use of unrealistic contexts and meaning in word problem solving: A case of second language learners in township schools. *International Journal of Research in Mathematics,* 1(1), 8 – 14.

Sepeng, P., & Madzorera, A. (2014). Sources of difficulty in comprehending and solving mathematical word problems. *Journal of Educational Science,* 6(2): *217-225.*

Sfard, A., Forman, E., & Kieran, C. (2001). Learning discourse: Sociocultural approaches to research in mathematics education. *Educational Studies in Mathematics, 46*(1-3), 1-12.

Sherrod, S. E., Dwyer, J., & Narayan, R. (2009). Developing Science and Mathematics Integrated Activities for Middle School Students. *International Journal of Mathematical Education in Science and Technology*.

Sidney, L. R. (1992). *Algebra 1. A practical approach.* University of Hawii. Gin & Company.

Siegel, C. (2005). Implementing a research-based model of cooperative learning. *The Journal of Educational Research,* 98(6), 339-349.

Slavin, R. E. (2011). Instruction Based on Cooperative Learning. In R. E. Mayer & P. A. Alexander (Eds.), *Handbook of Research on Learning and Instruction* (pp. 344-360). New York: Taylor & Francis.

Tajika, H. (1994). A cognitive component analysis of arithmetic word problem solving. In J. E. H. Van Luit (Ed.). *Research on Learning and Instruction of Mathematics in Kindergarten and Primary School* (pp. 242-250). Doetinchem. The Netherlands: Graviant Publishing Company.

Taplin, M. (2006). Mathematics through problem solving. http://www.cut-the-knot.org/arithematric/Wproblem.shtml. *Retrieved November, 21, 2018.*

Tsoho, L. T. (2011). Effects of Problem Solving and Student Centered Teaching Strategies on Students Geometry Performance and Retention in Junior Secondary Schools Kano State, Master's Thesis, ABU Zaria.

Umameh, M. A. (2011). A Survey of Factors Responsible for Students' Poor Performance in Mathematics in Senior Secondary School Certificate Examination (SSSCE) in Idah Local Government Area of Kogi State, Nigeria. Retrieved on 4th November, 2018 from https://www.academia.edu/7671293.

Van De Walle, J. A. (2004). (5th Edition). *Elementary and Middle School Mathematics: Teaching Developmentally*. New York: Pearson Education Inc.

Van Zoest, L., Jones, G., & Thornton, C. (1994). 'Beliefs about mathematics teaching held by pre-service teachers involved in a first grade mentorship program'. Mathematics Education Research Journal. 6(1): 37-55.

Verschaffel, L., Depaepe, F., & Van Dooren, W. (2014). Word problems in Mathematics education. In S. Lerman (Ed.), Encyclopedia of Mathematics education (pp. 641–645).Dordrecht, the Netherlands: Springer.

Verschaffel, L., Greer, B., & De Corte, E. (2000). Making Sense of Word Problems. Lisse, Netherlands: Swets and Zeitlinger.

Vilenius-Tuohimaa, P., Aunola, K., & Nurmi, J. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology, 28*, 409-426.

Vista, E. M. (2010). Developing comprehension of word problems in mathematics through grammar integration. Quezon: *Unpublished Master Thesis*. University of the Philippines.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Wang, H., & Posey, L. (2011). An inquiry-based linear algebra class, online submission. US China Education Review, 489-494.

Wells, C. S., & Wollack, J. A. (2003). An instructor's guide to understanding test reliability. Testing and evaluation services. University of Wisconsin. Retrieved 17 January 2019 from http://testing.wisc.edu/reliability.pdf.

West African Examination Council (2014). West Africa Senior School Certificate Examination, Chief Examiner's Report. Accra: West African Examination Council.

West African Examination Council (2015). West Africa Senior School Certificate Examination, Chief Examiner's Report. Accra: West African Examination Council.

West African Examination Council (2017). West Africa Senior School Certificate Examination, Chief Examiner's Report. Accra: West African Examination Council.

Yager, R. (1991). The constructivist learning model: Towards real reform in science education. The Science Teacher, 58(6), 52-57.

Yakubu, W. (2015). *Primary school mathematics teachers' conceptions and practices of constructivist instructional strategies*. An unpublished thesis presented to the Department of Basic Education, University of Education Winneba.

Yamarik, S. (2007). Does cooperative learning improve student learning outcomes? *Journal of Economic Education, 38* (3), 259 - 277

Yeo, K. (2009). Secondary 2 students' difficulties in solving non-routine word problems. *International journal for Mathematics teaching and learning*, 8, 1-30.

Yerushalmy, M. (2006). Slower algebra students meet faster tools: Solving algebraic word problems with graphing software. *Journal for Research in Mathematics Education, 37*(5), 356-387.

You, L. (2014). Cooperative learning: An effective approach to college English learning. *Theory & Practice in Language Studies, 4*(9), 1948-1953.

Zeitz, P. (1999). *The Art and Craft of Problem Solving.* John Wiley & Sons Inc.

APPENDIX A

PRE-TEST

Duration: 1 hour

Answer **all** questions   Name ………………....

1. The sum of four consecutive odd numbers is 168. Find the numbers.

2. When a certain number is subtracted from 26 and the result is multiplied by 9, the final result is 108. Find the number.

3. Kofi is 12 years older than Jessica. The sum of their ages is 74. Find their ages.

4. If $\frac{1}{4}$ of a number is added to $\frac{2}{3}$ of the same number, the result is $\frac{1}{2}$. Find the number.

5. Five less than a certain number is 4 more than three times the same number. Find the number.

6. Seven more than 4 times a certain number is 5 less than 2 times the same number. Find the number.

7. Two consecutive positive integers are such that, the greater added to twice the smaller gives 70.   Find the numbers.

8. When $\frac{1}{4}$ of a certain number is subtracted from $\frac{2}{5}$ of the same number, the result is 6. Find the number.

9. A certain number divided by 5 and 11 was added to the result. The final answer is 21. Find the number.

10. Emmanuel is three times as old as Alex. In five years' time, Emmanuel will be twice as old as Alex. What are their ages?

APPENDIX A1

MARKING SCNEME FOR PRE-TEST

QUESTION NUMBER	SOLUTION	MARKS
1	$Let\ x\ be\ the\ first\ odd\ number$	
	$x + x + 2 + x + 4 + x + 6 = 168$	B1
	$4x + 12 = 168$	
	$4x = 168 - 12$	M1
	$\frac{4x}{4} = \frac{156}{4}$	M1
	$x = 39$	
	$39, 41, 43, 45$	A1
2	$Let\ x\ represent\ the\ unknown\ number$	
	$9(26 - x) = 108$	B1
	$234 - 9x = 108$	M1
	$-9x = 108 - 234$	
	$-9x = -126$	M1
	$\frac{-9x}{-9} = \frac{-126}{-9}$	
	$x = 14$	A1
3	$Let\ x\ represent\ Jassica's\ age$	
	$Kofi's\ age = x + 12$	
	$x + x + 12 = 74$	B1
	$2x + 12 = 74$	
	$2x = 74 - 12$	M1
	$2x = 62$	
	$\frac{2x}{2} = \frac{62}{2}$	
	$x = 31$	
	$Jassica's\ age = 31\ years$	A1

	$Kofi's\ age = 31 + 12 = 43\ years$	A1
4	$Let\ x\ represent\ the\ unknown\ number$ $\frac{2}{3}x + \frac{1}{4}x = \frac{1}{2}$ $12 \times \frac{2}{3}x + 12 \times \frac{1}{4}x = 12 \times \frac{1}{2}$ $(multiplied\ through\ by\ LCM)$ $8x + 3x = 6$ $11x = 6$ $\frac{11x}{11} = \frac{6}{11}$ $x = \frac{6}{11}$	B1 M1 M1 A1
5	$Let\ x\ represents\ the\ unknown\ number$ $x - 5 = 3x + 4$ $x - 3x = 4 + 5$ $-2x = 9$ $\frac{-2x}{-2} = \frac{9}{-2}$ $x = \frac{-9}{2}\ or - 4.5$	B1 M1 M1 A1
6	$Let\ x\ represent\ the\ unknown\ number$ $4x + 7 = 2x - 5$ $4x - 2x = -5 - 7$ $2x = -12$ $\frac{2x}{2} = \frac{-12}{2}$	B1 M1

	$x = -6$	M1 A1
7	$Let\ x\ represent\ the\ smaller\ integer,$ $Greater\ integer = x + 1$ $x + 1 + 2x = 70$ $3x + 1 = 70$ $3x = 70 - 1$ $3x = 69$ $\frac{3x}{3} = \frac{69}{3}$ $x = 23$ $the\ integers\ are: 23, 24$	B1 M1 A1 A1
8	$Let\ x\ represent\ the\ unknown\ number$ $\frac{2}{5}x - \frac{1}{4}x = 6$ $20 \times \frac{2}{5} - 20 \times \frac{1}{4}x = 20 \times 6$ $(multiplied\ through\ by\ LCM)$ $8x - 5x = 120$ $3x = 120$ $\frac{3x}{3} = \frac{120}{3}$ $x = 40$	B1 M1 M1 A1
9	$Let\ x\ represent\ the\ unknown\ nimber$ $\frac{x}{5} + 11 = 21$ $5 \times \frac{x}{5} + 5 \times 11 = 5 \times 21$ $(Multiplied\ through\ by\ LCM)$	B1

	$x + 55 = 105$ $x = 105 - 55$ $x = 50$	M1 M1 A1
10	$Let\ x\ represents\ Alex's\ age$ $Emmanuel's\ age = 3x$ $2(x + 5) = 3x + 5$ $2x + 10 = 3x + 5$ $2x - 3x = 5 - 10$ $-x = -5$ $\frac{-x}{-1} = \frac{-5}{-1}$ $x = 5$ $Alex's\ age = 5\ years$ $Emmanuel's\ age = 3 \times 5 = 15\ years$	B1 M1 A1 A1

APPENDIX B

TREATMENT

Week 1

Translating algebraic word problems into mathematical symbols

Topic: Algebraic Word Problems

Sub-Topic: Algebraic Linear Equation Word Problems

Objectives: By the end of the one hundred and twenty (120) minutes lesson, students should be able to translate word problems involving linear equations into algebraic expressions.

Activity One

Students were asked to solve the question below

Musah is four years older than Anthony. The sum of their ages is 42 years. Find their ages.

The following equations were presented by some of the students

Let x represents Anthony's age

Student S1 wrote

Let x represents Anthony's age

Musah's age $= x + 4$

Hence, the equation $x + x + 4 = 42$

Another student S2 wrote $4x = 42$

Student S3 wrote $x + 4 = 42$

Other students also wrote the following equations

Let y represents Anhony's age

Student S4 wrote $y + 4 = 42$

Student S5 wrote $y = 42 + 4$

Student S6 wrote 4y+4 $= 42$

Student S7 wrote $y - 4 = 42$

Another student S8 presents the equation as

Let let k represents Anthony's age and m, Musah's age

$$k + 4m = 42$$

The students presented equations they formed on marker board.

Upon discussion, the class agreed on the correct equation, thus, the equation presented by student S1

$$x + x + 4 = 42$$

$$2x + 4 = 42$$

$$2x = 42 - 4$$

$$2x = 38$$

$$\frac{2x}{2} = \frac{38}{2}$$

$$x = 19$$

$$Anthony\ is\ 19\ years\ old, and\ Musah's\ age = 19 + 4 = 42\ years$$

The researcher then assisted the students to come out with the following guidelines for solving word problems.

1. Read the question thoroughly for understanding (reading the question more than once may enhanced your understanding). Identify the important information(s) present in the question. Assign a letter, say x, y, p, q or any alphabet of your choice to represent the unknown quantity or quantities in the question. Sketch a diagram where necessary.

2. Write an equation.

3. Solve the equation

4. Check the solution by substituting the answer into the original equation to verify whether it is correct and make sense.

Students were guided to identify the words/phrases that suggest the four basic operations (**Addition, Subtraction Multiplication, and Division**). Words/phrases such as ‘add’, ‘sum’, ‘more than’, ‘increased by’, ‘total of’, ‘combined’, ‘plus’, etc. indicate **ADDITION**. Phrases or words such as ‘less than’, ‘reduced by’, ‘decreased by’, ‘difference between’, ‘fewer than’, ‘difference of’, etc. indicate **SUBTRACTION**. Phrases or words such as ‘of’, ‘product’, ‘times’, ‘multiplied by’, ‘double’, ‘twice’, ‘thrice’ etc. indicate **MULTIPLICATION**. Words/phrases such as ‘divide’, ‘out of’, ‘ratio of’, share ‘quotient’, ‘percent’ (divided by 100), etc. signify **DIVISION**.

Activity Two

The researcher guided the students to translate algebraic word problems into algebraic expressions. With this, the researcher emphasized on reading and understanding the problem before attempting to translate it into algebraic expression or equation.

These are the examples the researcher went through with the students. The students are required to write an algebraic expression for each of the phrases.

1. Five more than a certain number

   Let x represents the unknown number

   The phrase 'more than' implies addition

   Students' response: $x + 5$ or $5 + x$

   A number more 14

   Let y represents the unknown number

   Students' response: $14 + y$ or $y + 14$
2. Ten less than a number.

   Let k represents the unknown number.

   I asked the students to write an expression for '10 less than k'.

   Students' response: $k - 10$

3. A number less than 17

   Let m represents the unknown number

   Students' response: 17 – m

4. A number decreased by 25

   Let q represents the unknown number

   Students' response: q – 25

5. The product of nine and a number

   Let y represents the unknown number

   Students' response: $9y$

After Activity Two, the researcher realised that the students were happy and showing interest in translating word problems into algebraic expressions. This was as a result of their active participation in the lesson.

Week 2

Topic: Algebraic Word Problems

Sub-Topic: Algebraic Linear Equation Word Problems

Objectives: By the end of the one hundred and twenty (120) minutes lesson, students should be able to: translate algebraic word problems into algebraic expressions.

Activity Three

1. Twice a number

   Let x represents the unknown number

   Students' response: $2x$

2. One-third of a number

   Let q represents the unknown number

   Students' response $\frac{1}{3}q$

3. The quotient of 8 and a number.

   The word 'quotient' implies division

   Let y represents the unknown number

Students' response $\frac{8}{y}$

4. The sum of a number and nine times the same number.

Let q be the unknown number

I asked the students to write an expression for '9 times q'

Students' response: $9q$

I then asked the students to write an expression for the sum of q and $9q$

Students' response: $q + 9q = 10q$

5. Ten less than the product of a number and 4.

Let k represents the unknown number

I asked the students to write an expression for the product of k and 4.

Students' response: $4k$

I then asked them to write an expression for 10 less than $4k$

They response: $4k - 10$

7. Twenty less than 14 percent of a number.

Let x be the unknown number

Students were asked to write 14 percent of x

Students' response: $\frac{14}{100}x$

The students were then asked to write an expression for 20 less than $\frac{14}{100}x$

Students' response: $\frac{14}{100}x - 20$

8. The quotient of 6, and 2 increased by a number.

Let k represents the unknown number

2 increased by k implies $2 + k$

Answer: $\frac{6}{2+k}$

9. A number less than seven

Let c represents the unknown number

Students' response 7 – c

10. The difference of half a number and 33

Let x represents the unknown number

I asked the students to write an expression for half of x

Students' response: $\frac{1}{2}x$

I then asked the students to write an expression for the difference of: $\frac{1}{2}x$ and 33

Students' response: $\frac{1}{2}x - 33$

11. Write each of the following phrases as an algebraic expression:

i) The difference of four times a number and 12

Let m represents the unknown number

I asked the students to write an expression for the phrase 4 times m

Students' response: $4m$

I asked the students to write an expression for the phrase 'the difference of $4m$ and 12

Students' response: 4m – 12

ii) Twice a number less than 54

Let x be the number.

Students' response: $54 - 2x$

iii) 2 times the difference of n and 9

I asked the students' to write an expression for the phrase "the difference of n and 9

Students' response: $n - 9$

I asked the students to write an expression for the phrase '2 times the difference of n and $9'$.

Students' response: $2(n - 9)$.

iv) When a certain number is added to 87 and the result is multiplied by four.

Let y represents the unknown number

1 asked students to write an expression for 'a number added to 87'

Students' response: $87 + y$

I then asked the students to write an expression for the phrase '4 multiplied by $87 + y$'

Students' response: $4(87 + y)$

v) Eight less than twice a number

Let x represents the unknown number

I asked the students to write for twice x

Students' response: $2x$

I then asked the students to write an algebraic expression for 8 less than $2x$

Students' response: $2x - 8$

Week 2 Continued

Topic: Algebraic Word Problems

Sub-Topic: Algebraic Linear Equation Word Problems

Objectives: By the end of the one hundred and twenty (120) minutes lesson, students should be able to solve algebraic linear equation word problems.

Activity Four

In this activity, I made the students to work in groups of five so that they will work together in order to maximize their learning activities. I guided the students to solve the prepared questions on algebraic word problems. I explained to the students that, when solving an equation, all terms containing ‘letters’ terms should be grouped on one side of the equal sign and all ‘number terms or constants’ on the other side of the equal sign. To obtain this,

1. Add the same quantity to each side of the equation

2. Subtract the same quantity from each side of the equation

3. Multiply each side of the equation by the same non-zero quantity

4. Divide each side of the equation by the same non-zero quantity

5. Check the solution to make the answer is correct and also make sense

Having taken the students through the steps involved in solving linear equations, I then guided them to solve the questions below.

1. The sum of two numbers is 147. The larger number exceeds the smaller by 55. Find the numbers.

I asked the students to read the question carefully and write down an equation which conforms to the given information and then solve for the unknown numbers.

The students came out with the following patterns and formula;

Let m represents the smaller number

Then, the larger number is $m + 55$.

The students' agreed on the equation below

$m + (m + 55) = 147$

$m + m + 55 = 147$

$2m + 55 = 147$

$2m + 55 - 55 = 147 - 55$ (Subtract 55 from both sides of the equation)

$2m = 92$

$\frac{2m}{2} = \frac{92}{2}$ (Divide both sides of the equation by 2)

$m = 46$

I then asked the students to check the solution by plugging the answer into the equation.

$m + (m + 55) = 34$, but $m = 46$

$146 + (46 + 55) = 147$

2. A father is three times as old as his son. In eight years' time, the father will be twice as old as the son. Determine the present ages of the father and the son. 114

Solution:

Step 1: read the well for understanding and use a letter to represent the son's age, let x = the son's present age,

Step 2: determine the father's present age using the son's age, thus $3x$

Step 3: determine their ages in eight years from now:

The son will be $(x + 8)$ years

The father will be $(3 + 8)$ years

Step 4: **form an** equation from the statement, thus

In eight years' time, father's age = two times the son's age

$$3x + 8 = 2(x + 8)$$

Step 5: Solve the equation

$$3x - 2x = 16 - 8$$

$$x = 8$$

Thus the son is 8 years now and the father is 24 years now.

3. When a certain number is subtracted from 14 and the result is multiplied by 5, the final result is 20. Find the number

Let y be the unknown number

I asked the students to write an expression for y subtracted from 14

Students' response: $14 - y$

I asked the students to multiply $(14 - y)$ *by* 5

Students' response: $5(14 - y)$

I asked the students' to write an equation for the question and solve it

Students' response: $5(14 - y) = 20$

$$70 - 5y = 20$$

$70 - 70 - 5y = 20 - 70$ (Subtract 70 from both sides of the equation)

$-5y = -50$

$\frac{-5y}{-5} \frac{-50}{-5}$ (Divide both sides of the equation by -5)

$y = 10$

4. The sum of three consecutive odd numbers is 345. Find the numbers.

I asked the students to read the question carefully and come out with a pattern or formula to solve the problem.

Let *x* represents the first odd even number

Then, the three odd numbers are: $x,\ (x + 2),\ (x + 4)$

$x + (x + 2) + (x + 4) = 345$

$x + x + 2 + x + 4 = 345$

$3x + 6 = 345$ (Add like terms)

$3x + 6 - 6 = 345 - 6$ (Subtract 6 from both sides of the equation)

$3x = 339$

$\frac{3x}{3} = \frac{339}{3}$ (Divide both sides of the equation by 3)

$x = 113$

The three odd numbers are: $113, 115, 117$

5. The sum of one-third of a number and six is 132. Find the number

I asked the students to translate the question into equation and solve the equation as well

Students' response: let q represents the unknown number

One-third of q: $\frac{1}{3}q$

Then, $\frac{1}{3}q + 6 = 132$

$3 \times \frac{1}{3}q + 3 \times 6 = 3 \times 132$ (Multiply through by LCM, 3)

$$q + 18 = 396$$

$q + 18 - 18 = 396 - 18$ (Subtract 18 from both sides of the equation)

$$q = 114$$

5. If $\frac{1}{5}$ of a certain number is added to two-third of the same number, the result is 26. Find the number.

The students were tasked to read the questions carefully and come out with patterns or formula for solving it.

Students' response:

Let k represents the unknown number,

Then, $\frac{1}{5}$ of $k = \frac{1}{5}k$ and

Two-third of $k = \frac{2}{3}k$

Hence, the equation: $\frac{2}{3}k + \frac{1}{5}k = 26$

$15\times\frac{2}{3}k + 15\times\frac{1}{5}k = 15\times 26$ (Multiply through by L.C.M, 15)

$10k + 3k = 390$

$13k = 390$

$\frac{13k}{13} = \frac{390}{13}$ (Divide both sides of the equation by 13)

$k = 30$

6. The sum of four consecutive odd numbers is 404. Find the numbers

Students' response:

Let m be the smallest even number, the numbers are:

$$m, \quad (m + 2), \quad (m + 4), \quad (m + 6)$$

Then,

$m + (m + 2) + (m + 4) + (m + 6) = 404.$

$m + m + 2 + m + 4 + m + 6 = 404$

$4m + 12 = 404$ (Add 'like terms')

$4m + 12 - 12 = 404 - 12$ (Subtract 12 from both sides of the equation)

$4m = 392$

$\frac{4m}{4} = \frac{392}{4}$ (Divide both sides of the equation by 4)

$m = 98$

The numbers are: 98, 100, 102, 104.

7. Jude is four times as old as Irene. In 8 years time, Jude will be twice as old as Irene. Find their ages.

Students' response:

Let x represents Irene's age

Jude's age: $4x$

$$2(x + 8) = 4x + 8$$

$$2x + 16 = 4x + 8$$

$$2x - 4x = 8 - 16$$

$$-2x = -8$$

$$\frac{-2x}{-2} \frac{-8}{-2}$$

$$x = 4$$

$$\text{Irene is 4 years old, and Jude's age: } 4 \times 4 = 16 \text{ years}$$

Week 3

Week 3 was used for revision. It was characterised by solving questions on algebraic linear equation word problems. The post-test was conducted the next day after the revision.

APPENDIX C

POST-TEST

Duration: 1 hour

Answer **all** questions Name …………………………………

1. When14 is subtracted from a certain number and the result is multiplied by 7, the final result is 112. Find the number.

2. The sum of three numbers is 87. The second number is four times the first number and the third number is 6 more than the second number. Find the numbers.

3. The sum of three consecutive even numbers is 270. Find the numbers.

4. If $\frac{2}{5}$ of a number is added to $\frac{1}{3}$ of the same number, the result is 22. Find the number.

5. Hakeem is four times as old as Eunice. In ten years' time, Abu will be two times as old as Eunice. Find their ages.

6. 21 less than 4 times a certain number is 15 less than twice the same number. Find the number.

7. When $\frac{2}{3}$ of a number is subtracted from $\frac{1}{3}$ of the same number, the result iss $\frac{3}{2}$. Find the number.

8. When a certain number is divided by 6 and 31 was added to the result, the final answer is 11. Find the number.

9. Four times the sum of a certain number and 10 is equal to twice the sum of the number and 5. Find the number.

10 Two consecutive integers are such that, the greater added to four times the smaller gives 256. Find the numbers.

APPENDIX C1

MARKING SCHEME FOR POST-TEST

QUESTION \NUMBER	SOLUTION	MARKS
1	$Let\ x\ be\ the\ unknown\ number$ $7(x - 14) = 112$	B1

	$7x - 98 = 112$ $7x = 112 + 98$ $7x = 210$ $\frac{7x}{7} = \frac{210}{7}$ $x = 30$	M1 M1 A1
2	$Let\ x\ represent\ the\ first\ number$ $Second\ number = 4x$ $Third\ number = 4x + 6$ $x + 4x + 4x + 6 = 87$ $9x + 6 = 87$ $9x = 87 - 6$ $9x = 81$ $\frac{9x}{9} = \frac{81}{9}$ $x = 9$ $the\ numbers\ are: 9, 36, 42$	B1 M1 M1 A1
3	$Let\ x\ represent\ the\ first\ even\ number$ $The\ second\ even\ number = x + 2$ $Third\ even\ number = x + 4$ $x + x + 2 + x + 4 = 270$ $3x + 6 = 270$ $3x = 270 - 6$ $3x = 264$ $\frac{3x}{3} = \frac{264}{3}$ $x = 88$ $The\ numbers\ are: 88, 90, 92$	B1 M1 A1 A1
4	$Let\ x\ represent\ the\ unknown\ number$	

	$\frac{1}{3}x + \frac{2}{5}x = 22$ $15 \times \frac{1}{3}x + 15 \times \frac{2}{5}x = 15 \times 22$ $(multiplied\ through\ by\ LCM)$ $5x + 6x = 330$ $11x = 330$ $\frac{11x}{11} = \frac{330}{11}$ $x = 30$	B1 M1 M1 A1
5	$Let\ x\ represents\ Eunice'\ age$ $Abu's\ age = 4x$ $2(x + 10) = 4x + 10$ $2x + 20 = 4x + 10$ $2x - 4x = 10 - 20$ $-2x = -10$ $\frac{-2x}{-2} = \frac{-10}{-2}$ $x = 5$ $Eunice = 5\ years\ old,$ $Abu = 4 \times 5 = 20\ years\ old$	B1 M1 A1 A1
6	$Let\ x\ represents\ the\ unknown\ number$ $4x - 21 = 2x - 15$ $4x - 2x = -15 + 21$ $2x = 6$ $\frac{2x}{2} = \frac{6}{2}$ $x = 3$	B1 M1 M1 A1
7	$Let\ x\ represents\ the\ unknown\ number$	

	$\frac{1}{3}x - \frac{2}{3}x = \frac{3}{2}$ $6 \times \frac{1}{3}x - 6 \times \frac{2}{3}x = 6 \times \frac{3}{2}$ $2x - 4x = 9$ $-2x = 9$ $\frac{-2x}{-2} = \frac{9}{-2}$ $x = \frac{-9}{2}\ or - 4.5$	B1 M1 M1 A1
8	$Let\ k\ represents\ the\ unknown\ number$ $\frac{k}{6} + 31 = 11$ $6 \times \frac{k}{6} + 6 \times 31 = 6 \times 11$ $(Multiplied\ through\ by\ LCM)$ $k + 186 = 66$ $k = 66 - 186$ $k = -120$	B1 M1 M1 A1
9	$Let\ represent\ the\ unknown\ number$ $4(x + 10) = 2(x + 5)$ $4x + 40 = 2x + 10$ $4x - 2x = 10 - 40$ $2x = -30$ $\frac{2x}{2} = \frac{-30}{2}$ $x = -15$	B1 M1 M1 A1
10	$Let\ x\ represent\ the\ smaller\ integer$ $The\ greater\ integer = x + 1$ $x + 1 + 4x = 256$ $5x + 1 = 256$ $5x = 256 - 1$	B1 M1

	$5x = 255$ $\frac{5x}{5} = \frac{255}{5}$ $x = 51$ $the\ integers\ are: 51, 52$	A1 A1

APPENDIX D

QUESTIONNAIRE FOR STUDENTS

Dear student,

This questionnaire seeks your view on the use of problem solving approach of teaching mathematics. Your sincere response will enable the researcher to use appropriate teaching method in teaching mathematics. Your maximum cooperation is needed as your response would be treated confidentially.

You are required to tick **[√]** in the space provided in each of the questions in the questionnaire

1. The use of problem solving approach of teaching in the classroom help me to understand mathematics easily. **Agree [ ]** **Undecided [ ]** **Disagree [ ]**
2. The use of problem solving approach in teaching mathematics is time-consuming. **Agree [ ]** **Undecided [ ]** **Disagree [ ]**
3. Given students the opportunity to participate actively in mathematics lessons improve their understanding. **Agree [ ]** **Undecided [ ]** **Disagree [ ]**

4. The use of learning mathematics in small groups made my learning easier and interesting. **Agree [ ] Undecided [ ] Disagree [ ]**

Thank you for completing this questionnaire

APPENDIX E

9) Represent the certain number by x

$\frac{x}{5} + 11 = 21$ B1

8/40

$\frac{x}{5}(5) + 11(5) = 21(5)$

$x + 55 = 105$ M1

$x = 105 - 55$ M1

$x = 50$ A1

3) Kofi 12 years than Jesica

if the sum of their ages is 74, then

$74 - 12 = 62$, B1

this means that the devision of 62 will give you Jesica's age.

So Jesica's age is $\frac{62}{2} = 31$ years M1 A1

and Kofi's age is $31 + 12 = 43$ years A1

8) Represent the certain number by x

$x - \frac{1}{4} - \frac{2}{5} = 6$ B0

the number is 6 A0

① let x be the odd number

$x+1+x+3+x+5+x=168$ B0

$1+x+9=168$ M0

$1+x=168-9$ M0

$\frac{1+x}{4}=\frac{159}{1+}$

$x=39.75$ A0

0/40

10

③ let x represent Alexs age

Immanuel's age $=x+3$

$2(x-5)=(x+3-5)$ B0

$2x-10=x-2$ M0

$2x-x=-2+10$ M0

$x=8$ A0

Q11 $\frac{N x}{14} = \frac{168}{4}$

$x = 42$

17/40

Q10 let x represent the age of Alex

$x = 3 = 3 + x$ B0

let P represent the age in five years time

$2x = 3x$ B0

$2x + 3x = 3x(5) - 2x$ M0

$15x + 2x$ M0

$= 17x$ A0

Q9 $\frac{x}{5} + 11 = 21$ B1 $= x + 55 = 105$

$x = 55 - 105$

$x + 55 = 105$ M1

$x = 105 - 55$ M1

$x = 50$ A1

Q8 $\frac{1}{4}x - \frac{2}{5} = 6$ B0

$\frac{1}{4}(6) = 6 + \frac{2}{5}$ M0 $\Rightarrow \frac{1}{4}x = \frac{8}{5}$ M0 A0

APPENDIX F

40/40

Q1

Let x be the number

$x - 14$

$7(x - 14) = 112$ M1

$7x - 98 = 112$ M1

$7x = 112 + 98$ M1

$\frac{7x}{7} = \frac{210}{7}$

$x = 30$ A1

Q3

Let x represent the first even number

x

$x + 2$

$x + 4$

$x + x + 2 + x + 4 = 270$ B1

$3x + 6 = 270$

$3x = 270 - 6$ M1

$\frac{3x}{3} = \frac{264}{3}$

$x = 88$ A1

∴ The numbers are 88, 90, 92 A1

Q6

Let y represent the unknown number

$4y - 21 = 2y - 15$ B1

$4y - 2y = -15 + 21$ M1

$\frac{2y}{2} = \frac{6}{2}$ M1

$y = 3$ A1

Q7

Let x represent the unknown number

$\frac{1}{3}x = \frac{2x}{3} = \frac{8}{2}$ B1

$2x - 4x = 9$ M1

$\frac{-2x}{-2} = \frac{9}{-2}$ M1

$x = \frac{-9}{2} = -4.5$ A1

Q10

Let x represent the smaller integer

greater integer $= x + 1$

$x + 1 + 4x = 256$ B1

$5x + 1 = 256$

$5x = 256 - 1$ M1

Q1

Let y represent the unknown number

$7(y-14) = 112$ B1

$7y - 98 = 112$ M1

$7y = 112 + 98$ M1

$\frac{7y}{7} = \frac{210}{7}$

$y = 30$ A1

34/40

Q2

Let x be the first number

4x and 4x+6

$x + 4x + 4x + 6 = 87$ B1

$9x = 87 - 6$ M1

$\frac{9x}{9} = \frac{81}{9}$

$x = 9$ A1 A0

Q8

Let x be the unknown number

$\frac{x}{6} + 31 = 11$ B1

$6 \times \frac{x}{6} + 6 \times 31 = 6 \times 11$

$x + 186 = 66$ M1

$x = 66 - 186$ M1

$x = -120$ A1

(9) Let x be the number

$x+10$ $x+5$

$4(x+10) = 2(x+5)$ B1

$4x + 40 = 2x + 10$ M1

$4x - 2x = 10 - 40$ M1

$\frac{2x}{2} = \frac{-30}{2}$

$x = -15$ A1

37/40

(6) Let y represent the unknown number

$4y - 21 = 2y - 15$ B1

$4y - 2y = -15 + 21$ M1

$\frac{2y}{2} = \frac{6}{2}$ M1

$y = 3$ A1

(4) Let m represent the unknown number

$\frac{1}{3}m + \frac{2}{5}m = 22$ B1

$(15)\ \frac{1}{3}m + (15)\ \frac{2}{5}m = (15)\ 22$

$5m + 6m = 330$ M1

$\frac{11m}{11} = \frac{330}{11}$ M1

$m = 30$ A1

APPENDIX G

SPEARMAN-BROWN RELIABILITY FORMULA

Steps to calculate the reliability of the algebraic linear equation word problems test

$$r = \frac{\sum(X - \ddot{x})(Y - \bar{Y})}{\sqrt{\sum(X - \ddot{x})^2} \times \sqrt{\sum(Y - \bar{Y})^2}}$$

$$Rsb = \frac{2r}{1 + r}$$

Where,

r = Pearson correlation between the split halves

X = Student's score on the first half of the test

$\ddot{x}$ = Mean score on the first half of the test

Y = Student's score on the second half of the test

$\bar{Y}$ = Mean score on the second half of the test

Rsb = Spearman-Brown reliability value

APPENDIX H

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF MATHEMATICS EDUCATION
[illegible]

25th February, 2019

Kade SHTS
P O BOX 25
Kade - E/R

Dear Sir/Madam

INTRODUCTORY LETTER

Mr. Amadu Braimah ([illegible]) is a graduate student who is pursuing an MPhil in Mathematics Education, at the Department of Mathematics Education, University of Education, Winneba. As part of his studies, he has been granted approval by the department's Graduate Board to undertake a research on **The Effects of problem-solving approach on senior high school students' performance in algebraic problems.**

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

We [illegible] consent and assistance.

22/03/19

Post-[illegible]
Department of Mathematics Education
University of Education, Winneba
(Cell: [illegible])

APPENDIX I

KADE SENIOR HIGH TECHNICAL SCHOOL

(GHANA EDUCATION SERVICE)

[illegible]

Our Ref: [illegible]

Your Ref: ______________

Post Office Box 134,
[illegible]
Eastern Region, Ghana.
E-mail: [illegible]
Mobile No.: [illegible]

DATE: 14th MAY 2019

MR AMADU SHAIMAH
UNIVERSITY OF EDUCATION, WINNEBA
P. O. BOX 25
WINNEBA

Dear Sir,

APPROVAL TO CONDUCT RESEARCH

I write to inform you that approval has been granted to your application to conduct research at Kade Senior High Technical School in fulfillment of your Mphil in Mathematics programmed.

I hope you will obey the school rules and regulations to enable you carry out your research work successfully.

Yours faithfully,

PAUL DOGBATSEY
(ASST. HEADMASTER ACA)
For: HEADMASTER

Asst. Headmaster [illegible]
Kade Snr. High Tech. School
Kade - E/R