IMPACT OF JIGSAW I LEARNING STRATEGY ON ATTITUDE AND PERFORMANCE IN ALGEBRA AMONG SENIOR SECONDARY SCHOOLS STUDENTS, ZARIA, NIGERIA.

BY

Ismaila Omobola, AKOWONJO
B.SC.(ED) MATHEMATICS
M.ED/EDUC/3301/11-12
(P15EDSC8058)

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN MATHEMATICS EDUCATION

DEPARTMENT OF SCIENCE EDUCATION,
FACULTY OF EDUCATION,
AHMADU BELLO UNIVERSITY, ZARIA-KADUNA, NIGERIA

MARCH, 2018

DECLARATION

I Ismaila Omobola AKOWONJO MED/EDUC/3301/11-12 (P15EDSC8058) declare that this dissertation entitled 'Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria – Nigeria, was conducted by me in the Department of Science Education, Ahmadu Bello University Zaria under the supervision of Prof Mamman Musa and Dr. S.M. Tudunkaya. The information derived from the literature reviewed has been duly acknowledged in the text and a list of references provided. No part of this dissertation was used previously for another degree or diploma in any university.

Ismaila Omobola AKOWONJO Date

CERTIFICATION

This dissertation entitled Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria – Nigeria by Ismaila Omobola AKOWONJO MED/EDUC/3301/11-12 (P15EDSC8058), met the regulations governing the award of Masters Degree in Mathematics Education of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

Prof. M. Musa — Date
Chairman, Supervisory Committee

Dr. S.M. Tudunkaya — Date
Member, Supervisory Committee

Prof. S. S. Bichi — Date
Head of Department of Science Education

Prof. S.Z. Abubakar — Date
Dean, School of Postgraduate Studies

DEDICATION

This Dissertation is dedicated to my Parents, Alhaji M.A. Akowonjo and Hajia S.O. Akowonjo.

ACKNOWLEDGEMENTS

I thank Almighty Allah (SWA) for giving me the opportunity to accomplish this work. My special appreciation goes to my reliable and efficient supervisors Prof. Mamman Musa and Dr. S.M. Tudunkaya who contributed immensely to the success of this research work. You are simply wonderful, and to you, I say a big thank you.

A very special thank you goes to Prof. C. Bolaji, who doubles as both a father and a mentor to me during the course of this work, indeed your advice, suggestions and constructive criticism have given this work the beautiful coloration it has. I'll always remain indebted to you sir.

I am also grateful to Dr M.O. Ibrahim (Postgraduate Coordinator) who never gets tired of tolerating me in the course of this research work. Special gratitude also goes to Prof. B.A. Maina (Head, Department of Educational Foundations and Curriculum) for his guidance and advice throughout the period of this research. May Allah reward you abundantly. I am also grateful to all other members of staff of Faculty of Education that have in one way or the other made this work a success.

I deeply appreciate the effort of the staff and students of WTC Zaria, GGSS Chindit, GSS chindit and Barewa College Zaria in making sure that this work is successful. God bless you all. Finally, to everyone who has in one way or the other contributed to the successful completion of this research, I say, may God bless you. Thank you all for being part of my success.

My deep appreciation goes to my parents; Alhaji and Hajia Akowonjo, my amiable wife; Olori Jummai Akowonjo, my children, Akram and Abdulrahman Akowonjo. My brothers; Prince Ola, AbdulGaniyu, AbdulAzeez and Mustapha Akowonjo, and my one

and only sister; Mulikat Aduni Dick, may Almighty Allah meet you all at your points of need.

I also appreciate the families of Dr. Mrs Nymata Salahu, late Alhaji Abdulmumeen Abdulkareem; may Allah forgive his sins and have mercy on his soul, my mother-inlaw; Hajia Bilkis Abdulkareem who for my sake became a prayer warrior, Hajia Kudi Sulaiman, Mr. Akin Buari, Engr. Tajudeen Abdulkareem, my godfather; Malam Umar Dabo Hussamatu and the entire Akowonjo family for their support, encouragement and prayers. May Allah continue to use you as instruments of positive change in the lives of people and reward you abundantly.

My special thanks go to my bosom friends; Emmanuel Yohana, Badaki Abdulrazak, Joseph Timayi and Aliyu Sulaiman Aliyu Bomo. I acknowledge and appreciate the contribution of the entire M.Ed. Mathematics 2011-2012 class for their continued support, may you receive divine guidance.

ABSTRACT

The study investigated the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria metropolis, Kaduna state, Nigeria. The study adopted a pretest, posttest quasi experimental design. The population consisted of 1757 senior secondary school students made up of 950 males and 807 females. Simple random sampling technique (ballot method) was used to select four schools as study sample with a total of 234 students. 115 made the experimental group while the control group was made up of 119 students. The research was guided by three research questions and three hypotheses. Three instruments: Students' Attitude Assessment Scale (SAAS), Pre - Algebra Achievement Test (PAAT) and Algebra Achievement Test (AAT) were used for data collection. The research questions were answered by descriptive statistics; mean and standard deviation while the hypotheses were analyzed using Mann-Withney Test and t test statistic at $p < 0.05$ level of significance. The findings of the study showed a significant difference between the attitude level of students taught algebra using Jigsaw I Learning Strategy and those taught by lecture method. It also reveals a significant difference between the performance of the experimental group and the control group in favour of the experimental group. Finally it showed that there is no significant difference between the performance of male and female students taught algebra using jigsaw I learning strategy. Based on the findings, it was recommended that Jigsaw I Learning Strategy should be used in teaching algebra and mathematics in general in senior secondary schools. It was also recommended that professional bodies like Mathematics Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) and research centers like Nigerian Educational and Research Development Council (NERDC) should incorporate Jigsaw I Learning Strategy in the science curriculum at every level of learning mathematics to encourage the use of Jigsaw I Learning Strategy in schools especially at primary and secondary schools.

List of Abbreviations

AAT:	Algebra Achievement Test
CG:	Control Group
EG:	Experimental Group
JS1LS:	Jigsaw I Learning Strategy
PAAT	Pre Algebra Achievement Test
SAAS:	Students Attitude Assessment Scale

List of Tables

Table		Page
3.1	Population of the Study	49
3.2	Sample of the Study	50
4.1	Descriptive Statistics on Performance between Experimental Group and Control Group	57
4.2	Descriptive Statistics on Attitude between Experimental and Control Group	58
4.3	Descriptive Statistics on Performance by gender in Experimental Group	58
4.4	t-test analysis on Performance between Experimental and Control group	59
4.5	Mann-Whitney test on Attitude between Experimental and Control Group	60
4.6	t-test analysis for Performance by gender in Experimental Group	61

List of Appendices

Appendix		Page
A:	Students Attitude Assessment Scale (SAAS)	77
B:	Pre-Algebra Achievement Test (pre test)	79
C:	Algebra Achievement Test (post test)	89
D:	Lesson plans for experimental group	94
E:	Jigsaw I Learning Strategy Activity sheet	105
F:	Jigsaw I Learning Strategy Manual	126
G:	Summary of students' performance in mathematics SSCE in Kaduna state from 2012-2015	126
H:	Mann-Withney Test Analysis for Attitude of Pre-test scores	127
I:	Mann-Withney Test Analysis for Attitude of Post-test scores	128
J:	t-test analysis of performance between Experimental and Control Group for Pre-test scores	129
K:	t-test analysis of performance between Experimental and Control Group for Post-test scores	130
L:	t-test analysis of performance between male and female students in the Experimental Group	131
M:	Introductory letter from Ministry of Education	132
N:	Pearson Product Moment Correlation Coefficient (R) of Pilot Test Score for SAAS	133

Table of Contents

Contents		**page**
Title page		i
Declaration		ii
Certification		iii
Dedication		iv
Acknowledgments		v
Abstract		vii
List of Abbreviations		viii
List of Tables		ix
List of Appendices		x
Table of Contents		xi
Operational Definition of Terms		xiv
CHAPTER ONE: THE PROBLEM		
1.1	Introduction	1
1.2	Statement of the Problem	4
1.3	Objectives of the Study	5
1.4	Research questions	5
1.5	Statistical Hypothesis	6
1.6	Significance of the Study	6

1.7 Scope and Delimitations of the Study 7

1.8 Basic Assumptions of the Study 9

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction 10

2.2 Theoretical Framework 11

2.3 Conceptual Framework 12

2.3.1 General Mathematics Teaching Methods 12

2.3.2 Concept of Cooperative Learning 14

2.3.3 Jigsaw I Learning Strategy 18

2.4 Concept of Algebra in Schools 21

2.5 Students' Performance in Algebra 33

2.6 Concept of Attitude 34

2.7 Gender Related to Performance in Algebra 38

2.8 Overview of Similar Studies 41

2.9 Implications of Literature Reviewed to Present Stud y 45

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction 47

3.2 Research Design 48

3.3 Population of the Study 48

3.4 Sample and Sampling Technique 49

3.5 Instrumentation 51

3.6 Pilot Study 52

3.7 Procedure for Data Collection 53

3.8 Procedure for Data Analysis 54

CHAPTER FOUR: DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1 Introduction 56

4.2 Data Presentation 57

4.3 Analysis 59

4.4 Discussion 61

4.5 Summary of Major Findings 64

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction 65

5.2 Summary of the Study 65

5.3 Conclusions 67

5.4 Contributions to Knowledge 68

5.5 Recommendations 68

5.6 Limitations of the Study 69

5.7 Suggestions for Further Studies 69

References 70

Appendices 77

Operational Definition of Terms

Achievement in algebra: This is a measure of the degree of success in performing tasks in algebra after teaching or instructions. In this study it refers to performance in algebra especially in WAEC examinations.

Conventional teaching method: In this study, it refers to teaching methods used to teach algebra which are mainly teacher centered. It is also referred to as lecture method of teaching.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Despite the important role Mathematics plays in our society, there had been persistent poor performance in the subject globally. Therefore, appropriate pedagogical approaches should promote not only students' memory and comprehension, but also facilitate their acquisition of competencies, skills of communication, independent thinking and team work (NASRV, 2008). Recently, although there have been efforts to change from teacher-centered approaches to student-centered approaches in an attempt to provide students with greater skills and knowledge, lecture-based teaching continues to be the most prevalent teaching method in institutions (Thanh-Pham, 2010).

Cooperative learning is a methodology that employs a variety of learning activities to improve students' understanding of a subject by using a structured approach which involves a series of steps, requiring students to create, analyze and apply concepts (Sahin, 2010). Cooperative learning utilizes ideas of Vygotsky, Piaget, and Kohlberg in that both the individual and the social setting are active dynamics in the learning process as students attempt to imitate real-life learning. It is a teaching strategy which allows students to work together in small groups with individuals of various talents, abilities and backgrounds to accomplish a common goal. Each individual team member is responsible for learning the material and also for helping the other members of the team learn. Students work until each group member successfully understands and completes the assignment, thus creating an "atmosphere of learning" (Johnson & Johnson, 2000).

Jigsaw I Learning Strategy is one of the cooperative learning models that reduces

conflict among students, promotes better learning, improves student motivation, and increases enjoyment of the learning experience (Sahin, 2010). This approach has been claimed to minimize the competitiveness in the learning environment by encouraging students to work together (David & Roger, 2010). In addition it has promoted more positive student attitudes toward their own learning, enhance more positive relationships between participants, develop self-esteem and cohesiveness, and improve learning skills (Sahin, 2010).

There are two major theoretical perspectives associated with cooperative learning: motivational and cognitive (Terwel, Herfs, Mertens, & Perrenet, 2010). First, students perceive because their success or failure is dependent upon their ability to work together as a group, students are likely to encourage each other to do whatever helps the group succeed. They are also more likely to help each other with the task(s) at hand. Elaborative thinking is promoted because students give and receive explanations more often (Shindler, 2010). Therefore, cooperative learning increases student motivation to do academic work (Heeden, 2013). The other theory is that cooperative learning helps students acquire critical thinking skills. Because cooperative learning creates a situation in which students must explain and discuss various perspectives, a greater understanding of the material is obtained.

Zakaria, Chin & Daud, (2010) argued that the conceptions, attitudes, and expectations of students regarding mathematics and mathematics teaching have been considered to be a very significant factor underlying their school experience and achievement. In their subsequent work, they further stated that students' success in achieving their goals encourages them to develop positive attitudes towards mathematics

and other problem solving activities. Positive attitudes are assumed to have significant effect on students' achievement. According to Abiam and Odok, (2013) the variable 'attitude' is one of the most potent factors that relates to achievement.

Studies on the impact of gender on mathematics achievement are yet to produce conclusive results. Swetman (2005) opined that girls develop negative attitudes towards mathematics as they grow older. However some other studies (Johnson & Johnson, 2005) also reported no significant gender differences in mathematics abilities and achievement. According to Brush, (2007) girls' confidence to study mathematics tends to match that of boys in the primary school years but this confidence deteriorates more rapidly as they go through secondary school. Kiamanesh, (2014) also observed that female students are less successful in learning mathematics, due to their low interest and confidence in learning mathematics and their low academic expectation. He further asserted that, girls initially have more positive attitudes towards mathematics than boys do, but as they continue in school, girls' attitudes become more negative.

The situation in Nigeria is that, academic performance in Mathematics education is still deplorably low, both in certificate and non-certificate examinations (Nwoji, 2009). This poor Mathematics performance is further worsened by gender imbalance leading to the problem which now constitutes a major research focus across the globe (UNESCO, 2003). This raises a serious concern since if the trend is unchecked it could undermine gender equity in Nigerian education system.

1.2 Statement of the Problem

A major problem facing Nigerian secondary education is the poor performance of students in core subjects, especially mathematics. Without a credit in mathematics the student cannot pursue most science and technology courses at institutions of higher learning in Nigeria, as such, Nigeria‘s quest for technological advancement and economic emancipation is being undermined by the continued poor mathematics achievement of senior secondary school students in external examinations.

It is common knowledge that the economies of the industrialized nations are driven by science and technology. Hence, Nigeria’s vision to be among the top 20 world largest economies by the year 2020 justifies the emphasis she places on “science, technical and vocational education” As a result, students in Nigeria are being encouraged to take up science-related subjects, and one subject that cuts across all sciences is mathematics.

In her match towards scientific and technological advancement, Nigeria needs good performance in mathematics for students at all levels of schooling. However, the poor performance of students in mathematics at the end of secondary education over the past decade is a big challenge to policy makers and stakeholders in Nigerian educational system. The poor achievement in mathematics in Nigerian secondary schools is assuming alarming proportions; as such ministry of education is worried about the poor performance in Mathematics in West African Examination Council. This poor performance is evidenced in WAEC result of year 2011 to 2015, where less than 40% of Kaduna state students obtained credit and above in mathematics in each of the 5 years.

Many factors have been identified by researchers as the causes of the low mathematics achievement among secondary school students. These include inadequate

facilities in the schools, inadequate qualified teachers, poor attitude towards the subject by the students and teachers, mathematics anxiety, culture/beliefs, gender stereotypes, lack of role models for girls, and the ineffective instructional methods used by teachers are among those widely examined in the study of the causes of poor performance in mathematics among students. Therefore, this study investigated the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria

1.3 Objectives of the Study

The main objective of this study is to find out the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria metropolis. Thus, the specific objectives of this research work were to;

1. Investigate the effectiveness of Jigsaw I Learning Strategy on Performance of Students in Algebra in senior secondary schools in Zaria.
2. Determine the influence of Jigsaw I Learning Strategy on Students' Attitude towards algebra in senior secondary schools in Zaria.
3. Investigate the effect of Jigsaw I Learning Strategy on Gender difference in Performance in Algebra.

1.4 Research Questions

Three research questions corresponding to the objectives of the study were asked, for answering. They include:

1 How does Jigsaw I Learning Strategy influence students' performance in algebra in senior secondary schools in Zaria metropolis?

2 How does Jigsaw I Learning Strategy influence students' attitude towards algebra in senior secondary schools in Zaria metropolis?

3 Is there any significant difference between the mean performance score of male and female students taught algebra using Jigsaw I Learning Strategy?

1.5 Statistical Hypotheses

The following hypotheses were stated and will be tested at $p < 0.05$ level of significance;

H_{01}: There is no significant difference between the performance of students taught algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method.

H_{02} There is no significant difference between the attitude of students taught algebra using Jigsaw I Learning Strategy and that of those taught by lecture method.

H_{03}: There is no significant difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy.

1.6 Significance of the Study

This research work is significant as the findings of this study could help improve classroom teaching and learning of mathematical concepts. It could hopefully reduce the problem of poor performance in mathematics as Jigsaw I Learning Strategy could boost learners' achievement level and create a relaxed, interactive and interesting classroom environment for effective learning.

The findings of this research could enjoin mathematics teachers to adopt Jigsaw I Learning Strategy in teaching as it could help break challenging mathematics concepts

into smaller sub-units, as such making the teaching process easier and more interesting for the teacher. It can also guide teachers on how to use Jigsaw I Learning Strategy as a means of enhancing participation of students in meaningful activities that involve social interaction amongst students.

The findings of this study could also help students in developing the right attitude towards learning mathematics, as Jigsaw I Learning Strategy could make complex mathematics concepts seems simple and as such interesting.

The result of this research could also help authors of mathematics textbooks by equipping textbook writers with appropriate teaching methods like the Jigsaw I Learning Strategy. This could help them in the structure and write-up of their future publications.

The findings of this research could also be useful to educational planners, school administrators and principals of schools. It could expose them to the realities of modern educational practices, and make them encourage their staff to adopt Jigsaw I Learning Strategy in their everyday teaching.

This study is also significant to professional bodies and associations such as Science Teachers Associations of Nigeria (STAN), Millennium Development Goal (MDGs), State Education Resource Centers (SERC) and other related bodies in training their prospective members on the effective use of Jigsaw I Learning Strategy. These, in the long run could avail the country with Jigsaw I Learning Strategy compliant personnel.

1.7 Scope and Delimitation of the Study

This research work investigated the impact of jigsaw I learning strategy on attitude and performance in algebra among senior secondary schools students in Zaria. The sample was four secondary schools from which SS2 students were used for the study. This was

because the study was on senior secondary school students; SS3 is an examination class while SS1 students were yet to fully settle down in the senior class, as such SS2 students are the most appropriate for the research. Five topics in algebra were used, namely: algebraic fraction, simultaneous equation, quadratic equation, arithmetic progression and geometric progression. These are the aspects of mathematics students were reported to perform poorly in our standardized school examinations (Iji, Ogbole and Uka, 2014). The research area covers all single-sexed public secondary schools in Zaria metropolis. Single-sexed schools were chosen because the researcher was also interested in finding the effect of Jigsaw I Learning Strategy on students' gender. Three instruments were used in the course of the research, they are; Pre Algebra Achievement Test (PAAT) pre test, Algebra Achievement Test (AAT) and Students Attitude Assessment Scale (SAAS). PAAT and AAT comprise of 50 objective questions of four multiple choices; this gave clarity in the choice of responses. SAAS also comprises of 30 statements on respondents' attitude towards algebra.

A simple random sampling technique (ballot method) was adopted and four senior secondary schools from a total of 10 schools. The selected schools were: Barewa College Zaria with 230 students, GGSS Zaria with 135 students, GSS Chindit with 216 students and GGSS Chindit female with 110 SS2 students. A simple random sampling technique (ballot method) was used to select one SS2 intact-class in each school. The total sample size was 234 students, which was in agreement with Krejcie and Morgan (1971) table for determination of sample size for a given population.

1.8 Basic Assumptions

For the purpose of this research work, it was assumed that; the students were being taught by qualified mathematics teachers.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

This research work was aimed at finding the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria. Three research questions corresponding to the stated objectives of the study were:

1 How does Jigsaw I Learning Strategy influence students' mean performance in algebra in senior secondary schools in Zaria metropolis?

2 How does Jigsaw I Learning Strategy influence students' attitude towards algebra in senior secondary schools in Zaria metropolis?

3 Is there any significant difference between the mean performance score of male and female students taught algebra using Jigsaw I Learning Strategy?

Correspondingly, three hypotheses were stated and tested at $p < 0.05$ level of significance. Hypothesis 1 stated that there is no significant difference between the mean performance of students taught algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method. Hypothesis 2 stated that there is no significant difference between the attitude of students taught algebra using Jigsaw I Learning Strategy and that of those taught by lecture method. While hypothesis 3 stated that there is no significant difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy.

The research design adopted for this study was Quasi-experimental research design was adopted for the study. The design comprised of experimental and control groups. Both groups were pre-tested using the instrument PAAT to ensure homogeneity among the

students at entry level. The experimental group was subjected to the treatment (Jigsaw I Learning Strategy) while the control group was taught using the conventional lecture method. After the treatment, AAT and SAAS were administered to both groups to determine their level of achievement and possible change of Attitude towards Algebra.

This chapter therefore, presented a detailed Theoretical and Conceptual Framework followed by critical analysis of Similar Studies and finally Implication of Literature Reviewed on the Study.

2.2 Theoretical Framework

This study was guided by the Constructivist theory of learning espoused by Piaget. The theory of constructivism suggests that learners construct knowledge out of their experiences. Constructivism is often associated with pedagogic approaches that promote active learning, or learning by doing like the Jigsaw I Learning Strategy.

Formalization of the theory of constr ivism is generally attributed to Jean Piaget, who articulated mechanisms by which knowledge is internalized by learners (Shayer & Efklides, 1992). According to the social constructivist approach, instructors have to adapt to the role of facilitators and not teachers (Bransford, 2000). Whereas a teacher gives a lecture that covers the subject matter, a facilitator helps the learner to get to his or her own understanding of the content. In the former scenario the learner plays a passive role and in the latter scenario the learner plays an active role in the learning process. The emphasis thus turns away from the instructor and the content, and towards the learner.

McMahon (2007) agrees that learning is a social process. He further states that learning is not a process that only takes place inside our minds, nor is it a passive development of our behaviours that is shaped by external forces and that meaningful

learning occurs when individuals are engaged in social activities. This is evident in the Jigsaw I Learning Strategy where there is social interaction by learners and teachers in the learning process in the group work.

Social constructivist scholars view learning as an active process where learners should learn to discover principles, concepts and facts for themselves, hence the importance of encouraging group work in learners. Jigsaw I Learning Strategy is one of the strategies that learners with different skills and backgrounds collaborate in tasks and discussions to arrive at a shared understanding of the truth in a specific field (Van Schaik, Van Oers and Terwel, 2010).

Social constructivism thus emphasizes the importance of the learner being actively involved in the learning process, unlike previous educational viewpoints where the responsibility rested with the instructor to teach and where the learner played a passive, receptive role (Tobias & Duffy, 2009).

2.3 Conceptual framework

2.3.1 General Mathematics Teaching Methods

A general problem facing learning of Mathematics in secondary schools thus leading to wanting performance in public examinations is the methods used by the teacher. Teachers should have insight and be resourceful in whatever methods they use. Practical work, investigations, group experiments and individual assignments are required more frequently than the usual 40 or 80 minutes lessons of lecturing. Once these activities are through, it is hoped that overall objectives of attitudes and students performance will be enhanced.

The popular method of teaching mathematics in secondary schools is the

Conventional teaching or the traditional teaching methods. This is the ordinary teaching methods used by teachers to deliver the contents of the syllabus to the learners (Macharia, Githua and Mboroki, 2009). They also opined that these methods are highly dependent on the skills of the teacher and not useful in enhancing learners interpersonal and communication skills. Most conventional methods of teaching mathematics are teacher-centered .The teacher demonstrates and summarizes the main points and there is surface learning of concepts, principles and skills (Dean, 2012). Teachers need to help students develop the skills they will use every day to solve mathematical and non-mathematical problems which include the ability to reason, explain and justify ideas. The teacher should also help students to use resources to find needed information to work with other people on a problem and to generalize to different situations as well as the traditional ability to carry out computations. Zemelman, Daniels and Hycles, 2013) describe the mathematic teachers' goal as helping all students to feel that mathematics is personally helpful and meaningful and to feel confident that he or she can understand and apply mathematics in life.

Traditional teaching like drilling, individual worksheet practice, lecturing and flashcards are considered effective depending on traditional definition of mathematics as merely collection of formulae, rules and procedures that must be memorized and mastered. However the current definition emphasizes that mathematics as a whole, is the study of structures and the relationships between things and a way to study and understand the world around us (Dean, 2012). Conventional teaching methods used in teaching mathematics increases students' anxiety and negative attitude towards the subject. There is

need to introduce a teaching method that will increase students performance and attitude toward mathematics, methods such as Jigsaw I Learning Strategy.

2.3.2 Concept of Cooperative Learning

Cooperative learning is a teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of subject matter (Sharan, 2010). They further stressed that each member of a team is responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. Students work through the assignment until all group members successfully understand and complete it.

The foundation of cooperative learning emerged from the work of a social psychologist, Sharan, (2010), who specialized in the study of social interdependence. According to Sharan cooperative learning is an approach of organizing classroom activities into academic and social learning experiences. Students must work in groups to complete the two sets of tasks collectively. Everyone succeeds when the group succeeds.

The primary benefit of cooperative learning is that it enhances students' self-esteem which in turn motivates students to participate in the learning process (Johnson & Johnson 2000). Cooperative efforts among students result in a higher degree of accomplishment by all participants (Slavin, 2001).

Heeden, (2013) defined Cooperative learning Model as an active education strategy with small groups in order that the students will develop the learning of both themselves and the group members. Cooperative learning Model according to Siltala, Suomala, Taatila and Keskinen, (2014) was defined as a learning approach that students

help learn from each other creating a small mixed groups towards a common purpose in an academic subject in both classroom and other environments.

2.3.2.1 Methods of Cooperative Learning

There are different methods of cooperative learning which uses collaborative approach in learning. According to Aronson, (2000) modern methods of Cooperative Learning include:

2.3.2.2 Group investigation

According to Sharan, (2010) in group investigation, students form interest groups within which to plan and implement an investigation, and synthesize the findings into a group presentation for the class. The teacher's general role is to make the students aware of resources that may be helpful while carrying out the investigation. It includes four important components: investigation, interaction, interpretation and intrinsic motivation. Investigation refers to the fact that groups focus on the process of inquiring about a chosen topic. Interaction is a hallmark of all cooperative learning methods, required for students to explore ideas and help one another learn. Interpretation occurs when the group synthesizes and elaborates on the findings of each member in order to enhance understanding and clarity of ideas. Finally, intrinsic motivation is kindled in students by granting them autonomy in the investigative process.

Implementation of group investigation proceeds in six steps. First, the teacher presents a multi-faceted problem to the class, and students choose an interest group. The problem posed here is particularly important, as a variety of re-actions from students is necessary for appropriate group formation. Teachers should avoid giving their own ideas or rejecting ideas from students. Second, groups plan their investigation the procedures,

tasks and goals consistent with the chosen subtopic. Third, groups carry out the investigation as planned in the above step. The teacher's role at this step is to follow the investigative process, offering help when required: suggesting resources, ensuring a variety of skills is being used. Fourth, groups plan their presentation. They evaluate what they have learned, and synthesize it into a form that can be understood by the class. Fifth, groups conduct the presentation. Finally, the teacher and students evaluate the investigation and resulting presentations (Sharan, 2010). Throughout the process, group representatives often make reports to the class, helping group members appreciate that they are part of a larger social unit.

2.3.2.3 Constructive Controversy

This cooperative approach was introduced by David Johnson and Roger Johnson in 1994. It had been researched and validated, and it's recognized as a leading model for developing robust and creative solutions to problems. Constructive Controversy is not about simply arguing and creating conflict for its own sake – it follows a formal procedure to manage controversy in a positive way using the following steps:

First, each team presents its case to the wider group. The objective is to help the group understand the particular choice, and convince people of its validity. Second, the other teams then have the opportunity to argue against the position. This is an open discussion – the presenting team listens to the counter-arguments, tries to disprove them, and defends its original position as best as it can. Third, the emphasis is on logic and critical thinking. Remind the teams that the overall objective is to gain a better understanding of all options in order to make the best decision possible. Encourage them to ask for solid data, and push the team to defend its conclusions. The next team presents

its case, and discussion follows. This continues until all teams have presented their positions. Lastly, it's the time to drop the advocacy roles, and bring the group together to make a final decision. Take the time to explore what people have learned from the Constructive Controversy process, and then bring together ideas to create a final proposal.

2.3.2.4 Student Teams-Achievement Divisions (STAD)

In Student Teams-Achievement Divisions (STAD), students are assigned to four-member learning teams that are mixed in performance level, gender, and ethnicity (Slavin, 2011). The teacher presents a lesson, and then students work within their teams to make sure that all team members have mastered the lesson. Finally, all students take individual quizzes on the material, at which time they may not help one another. Students' quiz scores are compared to their own past averages, and points are awarded on the basis of the degree to which students meet or exceed their own earlier performance. These points are then summed to form team scores, and teams that meet certain criteria may earn certificates or other rewards.

The STAD method is most appropriate for teaching well-defined objectives with single right answers, such as mathematical computations and applications, language usage and mechanics, geography and map skills, and science facts and concepts. However, it can easily be adapted for use with less well-defined objectives by incorporating more open-ended assessments, such as essays or performances.

2.3.2.5 Cooperative Integrated Reading and Composition (CIRC)

According to Slavin, (2011) this is a comprehensive program for teaching reading and writing in the upper elementary grades. Students work in four-member cooperative learning teams. They engage in a series of activities with one another, including reading to

one another, making predictions about how narrative stories will come out, summarizing stories to one another, writing responses to stories, and practicing spelling, decoding, and vocabulary.

They also work together to master main ideas and other comprehension skills. During language arts periods, students engage in writing drafts, revising and editing one another's work, and preparing for publication of team books. Three studies of the CIRC program have found positive effects on students‟ reading skills, including improved scores on standardized reading and language tests (Slavin, 2011).

2.3.3 Jigsaw I Learning Strategy

Jigsaw I Learning Strategy is a cooperative learning technique which was first developed in the early 1970‟s by Elliot Aronson and his associates. Since then, many schools have used the technique with success. According to Aronson (2000) Jigsaw groups are developed in the class whereby each student in the group is assigned his/her part to work on. Then the groups are reconstituted with students having identical assignment put together. Then the students go back to their initial Jigsaw groups to present their well organized report to the group. Just like jigsaw puzzle, each piece (Student part) is essential for the completion and full understanding of the final product. Schul, (2011) explains Jigsaw I Learning Strategy as a cooperative learning strategy that enables each student assigned to a group or 'home' group to specialize in one aspect of a learning unit, students meet with members from other groups who are assigned the same aspect of a topic and after mastering the material, return to the 'home group" as experts and teach this material to the group members.

According to Schul, Jigsaw I Learning Strategy can be used whenever material can

be segmented into separate components. Each group member becomes an expert on a different concept or procedure and teaches it to the group. In their opinion Bukunola & Idowu, (2012) describe Jigsaw I Learning Strategy as a Cooperative Learning Model that involves small groups of 4-6 students teaching each other subject matters which they have become "experts" with success dependent upon students' cooperation. Davidson, (2005) points out the following benefits of Jigsaw I Learning Strategy as they apply to mathematics teaching;

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

Jigsaw I Learning Strategy steps according to Aronson (2000) are:

1. The teacher divides the students into 4 or 5 people's jigsaw groups which should be diverse of gender, ethnicity, race and ability.
2. The teacher divides the lesson into 4 or 5 segments.
3. The teacher gives each student in each group a segment of what is to be learned.
4. The students are given time to write down their segment and become familiar with it.
5. Students from each jigsaw group join other students assigned the same task to form "expert groups". The teacher gives the expert groups time to discuss their specific task and also refer from the text books.

6. The teacher brings the students back to their jigsaw groups.

7. The teacher asks each student to present his or her task to the group.

8. The teacher floats from group to group observing the process. If any group is having any trouble, the teacher makes an intervention.

Several researches have been conducted on Jigsaw I Learning Strategy and its effect on teaching and learning scenario. Some of their findings are; Jigsaw Learning Strategy creates an environment of active, involved, exploratory learning. This method fits in well with the constructivist approach when students become actively involved in defining questions in their own language and working out answers together instead of reproducing material presented by the teacher or the textbook. Jigsaw I Learning Strategy allows students to exercise a sense of control on task (Sharan & Sharan, 1976). Involving students actively in learning encourages students' responsibility in learning (Baird & White, 1984). Jigsaw Learning Strategy has the effect to elevate students to the teacher's level and create a high expectation that they have the ability to obtain and understand knowledge themselves.

In their opinion, Jigsaw I Learning Strategy promotes a learning goal rather than a performance goal. This approach focus on the process of learning and how individuals function within the groups but not necessarily competitively as opposed to other conventional methods which emphasize competitive testing to access students' competence and create an evaluation hierarchy based upon grades.

Jigsaw I Learning Strategy have also been discovered to have improved students' academic achievement and attitudes towards self, peers and school (Johnson, 2009). When individuals get stuck they are more likely to give up; groups are much more likely to find

ways to keep going. In their work, Brown, and Ciuffetelli, (2009) argued that students often learn more by listening to their peers than they do by listening to an authority figure like a teacher. Weaker students improve their performance when grouped with achieving students. In their study, Brown, and Ciuffetelli, (2009) found out that student of low achievement benefited from participation in groups heterogeneously composed on achievement in comparison to participation in homogenously low-achieving groups. Many students are hesitant to speak out and offer opinions publicly in a traditional classroom setting for fear of appearing foolish. But in cooperative learning students explore alternative solutions to problems in a safe environment. In addition to shifting responsibility for learning onto students, Jigsaw learning provides an opportunity for students to demonstrate their knowledge by helping their peers, an especially important advantage over the lecture method or class discussion form of teaching, (Schul, 2011).

Students are given a leeway to decide how they will function and what their group's product will be. The use of Jigsaw I Learning Strategy promotes high achievement and class attendance (Schul, 2011). He further said students who develop personal professional relations with teachers by getting to know them, and who work on projects outside the class, achieve better results and tend to stay in school. Teachers get to know and understand their students well when cooperative learning occurs and the teachers are able to know and deal with the student's problems hence catering for individual differences in the class.

2.4 Concept of Algebra in Schools

Algebra is a branch of mathematics that uses mathematical statements to describe relationships between things that vary over time. These variables include things like the

relationship between supply of an object and its price. When we use a mathematical statement to describe a relationship, we often use letters to represent the quantity that varies, since it is not a fixed amount. These letters are referred to as variables. According to Herstein, (2005) algebra is the study of mathematical symbols and the rules for manipulating these symbols. It is a unifying thread of almost all the mathematics, as such it includes everything from elementary equation solving to the study of abstraction such as groups, rings and fields (Herstein, 2005). Algebra is a branch of mathematics concerning the study of structure, relation and quantity (en.m.wikipidia.org).

Henderson & David (2008) defined algebra as a division of mathematics designed to help solve certain types of problems quicker and easier. Algebra is based on the concept of unknown values called variables, unlike arithmetic which is based entirely on known number values. The basic unit of an algebraic expression is a 'term'. In general, a term is either a number or a product of a number and one or more variables. Below is the term ($-3ax$). The numerical part of the term, or the number factor of the term, is what we refer to as the numerical coefficient. This numerical coefficient will take on the sign of the operation in front of it. In this case the numerical coefficient is '–3' and the variables in the term are 'a' and 'x'. Terms such as 'xz' may not appear to have a numerical coefficient, but they do. The numerical coefficient is '1'.

An algebraic expression is a meaningful collection of numbers, variables, and signs, positive or negative, of operations that must make mathematical and logical sense. Algebraic expression contain any number of algebraic terms connected using signs of operation; addition, subtraction, multiplication, and division but do not contain an equality sign (=). An example of an expression is; $-3ax + 11wxy$. Here, the signs of operation

separate the expression into two terms. The first term is '$-3ax$ ' and the second term is '$11wxy$'. The addition sign separates the two terms.

Algebra began with computations similar to those of arithmetic, with letters standing for numbers. This allows proofs of properties that are true no matter which numbers are involved. For example, in quadratic equation $ax^2 + bx + c = 0$. a, b and c can be any number except that a can not be 0 and the quadratic formula can be used quickly and easily find the value of the unknown quantity x. As it developed, algebra was extended to other non numeric objects, such as vectors, matrices and polynomials. Today, algebra has grown until it includes many branches of mathematics.

Algebra has two main branches; Elementary algebra and Abstract algebra. Special attention was given to elementary algebra for the purpose of this study. Elementary algebra is vast and covers a number of concepts. These concepts include: Introduction to algebraic quantities, Algebraic equations, Algebraic inequalities, Simplifying expressions and radicals, Exponentiation and logarithms, Linear equation in one and two variables, algebraic fractions, Quadratic equations, Factorization, Polynomials, and Graphing. Special attention was given to algebraic fractions, simultaneous equations, quadratic equations, arithmetic progression and geometric progression.

2.4.1 Quadratic Equation

An equation is a mathematical statement that two expressions are equal. The following three statements are equations (Rich and Schmidt, 2014)

$4 + 5 = 9$ $x - 35 = 52$ $x + 3 = 15$

The first equation, $4 + 5 = 9$, contains only numbers; the other two, however, also contain variables. All three contain two expressions separated by an equal sign. The

equation may also be balanced by a device called a variable. A variable is an unknown number represented by any letter in the alphabet. The value of each variable must remain the same in each problem. Algebra is one of the main branches of pure mathematics that covers polynomials, terms, geometry, topology, fractions, number theory and equations. The mathematical statements that describe relationships are expressed using algebraic terms, expressions, or equations.

Quadratic equation is any equation having the form $ax^2 + bx + c = 0$ Where x represents an unknown, and a, b and c represent numbers such that 'a' is not equal to 0. If$a = 0$, then the equation is linear, not quadratic. a, b and c are the coefficients of the equation, and may be distinguished by calling them, respectively, the quadratic coefficient, the linear coefficient and the constant or free term (Rich and Schmidt, 2014).

Rich and Schmidt argued that quadratic equation refers to second-degree algebraic equations, It may have one or more variables, but the standard form in a single variable $x$is given by $ax^2 + bx + c = 0$ where a, b, and c are constant in the equation (referred to as coefficients). Because the quadratic equation involves only one unknown, it is called "univariate". Therefore it is a polynomial equation, and in particular it is a second degree polynomial equation since the greatest power is two. Quadratic equations can be solved by factoring, by completing the square, by using the quadratic formula, or by graphing.

2.4.2 Solution of Quadratic Equations

Solving equations is a fundamental theorem of Algebra and Mathematics as a whole, since all the different aspects incorporate some sort of solving equations. If the equation is quadratic, it may have two solutions, one solution, or no solutions at all; depending on the value of the discriminant. You can solve a quadratic equation

algebraically by three possible methods; Factoring by Inspection, Quadratic Formula and Completing the Square.

2.4.3 Factoring by Inspection.

It may be possible to express a quadratic equation $ax^2 + bx + c = 0$ as a product $(px + q)(rx + s) = 0$. In some cases, it is possible, by simple inspection, to determine values of p, q, r, and s that make the two forms equivalent to one another. If the quadratic equation is written in the second form, then the "Zero Factor Property" states that the quadratic equation is satisfied if $px + q = 0$ or $rx + s = 0$. Solving these two linear equations provides the roots of the quadratic.For most students, factoring by inspection is the first method of solving quadratic equations to which they are exposed. If one is given a quadratic equation in the form $ax^2 + bx + c = 0$, the sought factorization has the form $(x + q)(x + s)$, and one has to find two numbers q and s that add up to b and whose product is c (this is sometimes called "Vieta's rule" and is related to Vieta's formulas). The more general case where 'a' does not equal 1 can require a considerable effort in trial and error guess-and-check, assuming that it can be factored at all by inspection. Except for special cases such as where b = 0 or c = 0, factoring by inspection only works for quadratic equations that have rational roots. This means that the great majority of quadratic equations that arise in practical applications cannot be solved by factoring by inspection.

2.4.4 Quadratic Formula

The quadratic formula always works. Whether an equation factors or not, you can always use the quadratic formula to get the answers. The quadratic formula can be rather messy and cumbersome, and you can make errors more easily during this method than by

factoring. If an equation can be written in the form $ax^2 + bx + c = 0$, then the solutions to that equation can be found using the quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

This method is especially useful if the quadratic equation is not factorable.

Example: Solve the quadratic equation $6x = 4x^2 + 1$ using the quadratic formula.

Set the equation equal to 0:

$$-4x^2 + 6x - 1 = 0$$

The coefficients for the quadratic formula are $a = -4$, $b = 6$, and $c = -1$

$$x = \frac{-(6) \pm \sqrt{6^2 - 4(-4)(-1)}}{2(-4)}$$

$$x = \frac{-6 \pm \sqrt{20}}{-8}$$

$$x = \frac{-6 \pm 2\sqrt{5}}{-8}$$

$$x = \frac{2\left(-3 \pm \sqrt{5}\right)}{-8}$$

$$x = \frac{-3 + \sqrt{5}}{-4}, \frac{-3 - \sqrt{5}}{-4}$$

You can also write the answers as $x = \frac{3 - \sqrt{5}}{4}, \frac{3 + \sqrt{5}}{4}$.

2.4.5 Completing the Square

The most complicated, though itself not very difficult, technique for solving

quadratic equations works by forcibly creating a trinomial that's a perfect square (hence the name). Here are the steps to follow:

1. Put the equation in form $ax^2 + bx = c$. In other words, move only the constant term to the right side of the equation.
2. If $a \neq 1$, divide the entire equation by a.
3. Add the constant value $\left(\frac{b}{2a}\right)^2$ to both sides of the equation.
4. Write the left side of the equation as a perfect square.
5. Take the square roots of both sides of the equation, remembering to add the "±" symbol on the right side.
6. Solve for x.

Example: Solve the quadratic equation by completing the square.

$$2x^2 + 12x - 3 = 0$$

Move the constant so it alone is on the right side:

$$2x^2 + 12x = 3$$

Divide everything by the leading coefficient, since it's not 1:

$$x^2 + 6x = \frac{3}{2}$$

Half of the x-term's coefficient squared, $\left(\frac{6}{2}\right)^2, = 9$. Add that value to both sides of the equation: $x^2 + 6x + 9 = \frac{3}{2} + \frac{18}{2}$ s

The left side is a perfect square:

$$(x+3)^2 = \frac{21}{2}$$

$$\sqrt{(x+3)^2} = \pm\sqrt{\frac{21}{2}}$$

$$x = -3 \pm \sqrt{\frac{21}{2}}$$

2.4.6 Discriminant

In the quadratic formula, the expression inside the square root sign is called the discriminant of the quadratic equation, and is often represented using an upper case *D* or an upper case Greekdelta (Sterling, 2010).

$$\Delta = b^2 - 4ac.$$

A quadratic equation with real coefficients can have either one or two distinct real roots, or two distinct complex roots. In this case the discriminant determines the number and nature of the roots. There are three cases:

1 If the discriminant is positive, then there are two distinct roots

$$\frac{-b+\sqrt{\Delta}}{2a} \quad \text{and} \quad \frac{-b-\sqrt{\Delta}}{2a},$$

both of which are real numbers. For quadratic equations with rational coefficients, if the discriminant is a square number, then the roots are rational in other cases they may be quadratic irrationals.

2 If the discriminant is zero, then there is exactly one real root

$$-\frac{b}{2a},$$

sometimes called a repeated or double root.

3 If the discriminant is negative, then there are no real roots. Rather, there are two distinct(non-real) complex roots

$$\frac{-b}{2a} + i\frac{\sqrt{-\Delta}}{2a} \quad \text{and} \quad \frac{-b}{2a} - i\frac{\sqrt{-\Delta}}{2a},$$

which are complex conjugates of each other. In these expressions *i* is the imaginary unit.

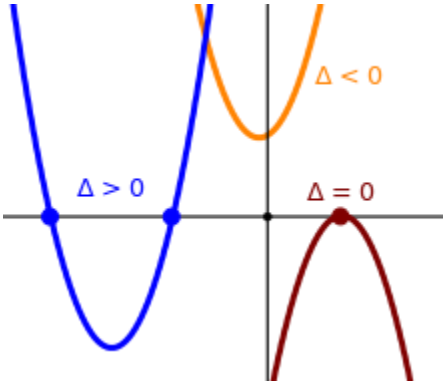


Figure 2.1 Discriminant signs

2.4.7 Simultaneous Equations

The terms simultaneous equations and systems of equations refer to conditions where two or more unknown variables are related to each other through an equal number of equations. Consider the following example:

$$x + y = 24$$
$$2x - y = -6$$

For this set of equations, there is but a single combination of values for x and y that will satisfy both. Either equation, considered separately, has an infinitude of valid (x,y) solutions, but together there is only one. Plotted on a graph, this condition becomes obvious (see figure 2.2)

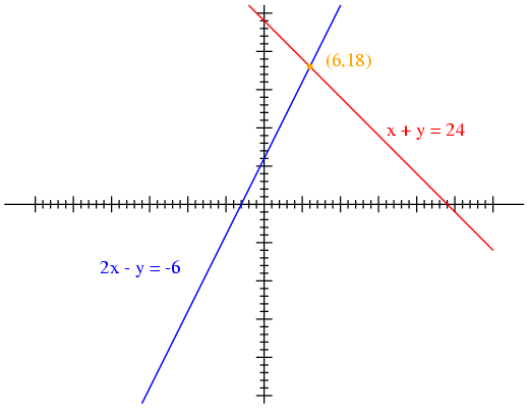


Figure 2.2

Each line is actually a continuum of points representing possible x and y solution pairs for each equation. Each equation, separately, has an infinite number of ordered pair (x,y) solutions. There is only one point where the two linear functions x + y = 24 and 2x - y = -6 intersect (where one of their many independent solutions happen to work for both equations), and that is where x is equal to a value of 6 and y is equal to a value of 18.

Usually, though, graphing is not a very efficient way to determine the simultaneous solution set for two or more equations. It is especially impractical for systems of three or more variables. In a three-variable system, for example, the solution would be found by the point intersection of three planes in a three-dimensional coordinate space. Simultaneous equations are solved exactly either by the substitution method or the elimination method. An approximate solution can be found by using the graphical method.

2.4.8 Substitution Method

Several algebraic techniques exist to solve simultaneous equations. Perhaps the easiest to comprehend is the substitution method. Take, for instance, our two-variable example problem:

$$y - 3x = 0$$
$$x + y = 8$$ Solution:

Label the equations as follows:

$$y - 3x = 0 \quad \ldots(1)$$
$$x + y = 8 \quad \ldots(2)$$

From (1) we have:

$y = 3x$ ...(3)

Substituting $y = 3x$ in (2) gives:

$$x + 3x = 8$$
$$4x = 8$$
$$\frac{4x}{4} = \frac{8}{4}$$
$$x = 2$$

When $x = 2, y = 3 \times 2$ {From (3)}
$= 6$

So, the solution is (2, 6).

2.4.9 Elimination Method

To solve the simultaneous equations, make the coefficients of one of the variables the same value in both equations. Then either add the equations or subtract one equation from the other (whichever is appropriate) to form a new equation that only contains one variable. This is referred to as eliminating the variable. To add two equations, add the left hand expressions and right hand expressions separately. Similarly, to subtract two

equations, subtract the left hand expressions from each other, and subtract the right hand expressions from each other. The following examples will make this clear.

Example 1: Consider these equations:

2x - 5y = 1

3x + 5y = 14

The first equation contains a '-5y' term, while the second equation contains a '+5y' term. These two terms will cancel if added together, so we will add the equations to eliminate 'y'.

To add the equations, add the left side expressions and the right side expressions separately.

2x - 5y = 1
+
3x + 5y = 14
(2x - 5y) + (3x + 5y) = 1 + 14
Simplifying, we have:
5x = 15
Therefore 'x' is 3.
By substituting 3 for 'x' into either of the two original equations to find 'y'.
Therefore, y = 1.

2.4.10 The Graphical Method

The graphical solution of simultaneous equations is given by the point of intersection of the graphs. Consider the $y - 3x = 0$ and $x + y = 8$ simultaneous equations

Consider also the graph of $y - 3x = 0$

$$y - 3x = 0$$

That is, $y = 3x$

It passes through the origin (0, 0) and the point (1, 3).

Consider the graph of $x + y = 8$.

x-intercept: When $y = 0$, $x = 8$.

y-intercept: When $x = 0$, $y = 8$.

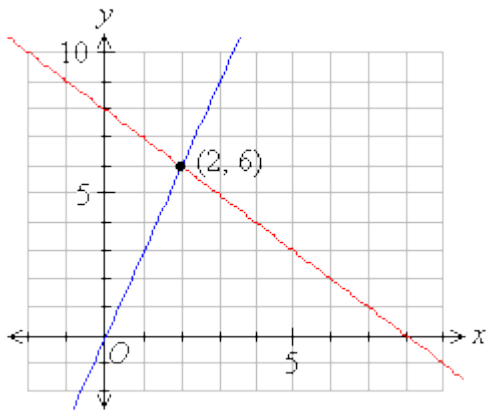


Figure 2.3: graph of $y - 3x = 0$ and $x + y = 8$

The lines intersect at (2, 6). So, the solution is (2, 6) as shown in the diagram.

2.5 Students' Performance in Algebra

Given a rapidly changing world, today's student success hinges on the students' abilities to organize and apply algebra in the solution of meaningful problems. Several factors have been identified by researchers as major predictor of students' performance in algebra and mathematics in general. Among these factors are students' learning style, Students' Self-Confidence, Students' Study Habits, Teachers-Students Relationship and Student's Attitude towards Mathematics.

The need to improve the standard of living in Nigeria through the advancement in science and technology has made Government at all levels and stakeholders in education to be more concerned now than ever about the poor performance of students in Mathematics. Since the general belief is that mathematics is a difficult and challenging concept, this section dwells on possible ways of improving achievement of students in

mathematics.

A study on Some Student Personal Variables as Predictors of Mathematics Achievement in Secondary Schools in Central Cross River State – Nigeria concluded that in tackling poor performance in Mathematics, variables within the learner need to be addressed, as they also contribute to explain or predict learners' performance in Mathematics (Coombs, 2003).

Mathematics is one of the weakest subjects having a low performance in the 2006 National Achievement Test and Division Achievement Test (Denwigwe & Ikeotuonye, 2008) Subscribing to the belief that the quality of education is measured by the performance of students, every educator feels the imperative need to identify variables that could be used as a tool in predicting performance in Mathematics subjects.

2.6 Concept of Attitude

Attitude is commonly referred to as beliefs and feelings related to a person or event and their resulting behavior, according to Myres (2000). This means that when individuals have to respond quickly to something, the feeling can guide the way they react. Attitude is a non-cognitive factor that influences learning. Psychologists like Greenwald, McGhee & Schwarts (2002) agree that knowing people's attitudes predicts their actions. According to them, attitude is an association between an object and our evaluation of it. When this association is strong, the attitude becomes accessible. They said further that one acquires attitude in a manner that makes one sometimes potent, sometimes not. For this reason, they concluded that attitudes predict actions if other influences are minimized, if it is specific to the action and it is potent. Attitude is considered as a silent predisposition of people to concepts, ideas and beliefs (Falaye,

2006). He also said ‘Attitude as a construct can either be positive or negative’. Many researchers opined that positive attitude to learning correlates positively with achievement and that the more positive the attitude, the more likely the students perform in any subject (Norton and Rennie, 2010). Attitude is one of those constructs which has attracted the attention of the researchers in education.

Norton and Rennie identified number of factors that can inform the attitude a learner to be any of the following; teaching method, parents influence, gender, students' cognitive styles, career interests, societal view, teachers’ attitude, subject matter, peer influence. Attitude therefore can be summarized as the disposition towards a course, which may be a favorable or unfavorable disposition it may be good or poor (commonly referred to as negative or positive). It is an expression of the level of like or dislike, interest or disinterest. When there is ‘like’ or ‘interest’ which is caused due to intrinsic or extrinsic value or due to cause and effect, then there may tend to be good attitude towards a certain course. On the other hand, if there is ‘dislike’ or ‘disinterest’ this tends to engender a poor attitude. The ‘like’ or otherwise’ the ‘interest or otherwise’, themselves could be as a result of individual makeup, innate characteristics or experience.

2.6.1 Attitude and Performance of Students in Mathematics

In considering the academic achievement of students as being greatly influenced by their attitude towards different subjects, findings revealed that attitude affects achievement either positively or negatively. Pajares and Kranzler, (2011) define mathematics attitude as how an individual feels about mathematics. Li, (2011) contend that when students were taken to a science centre and given exposure to space science, the students’ attitude towards mathematics was positively affected.

From past literature, it was found that some scholars developed a theory that could be used to explain the relationship between attitude and academic achievement. Zakaria, Solfitri, Daud, and Abidin, (2013) constructed the value-expectancy model by arguing that a person's attitude determined his/her intended behavior, which could ultimately affect the outcome. Based on the model, he stated that a person would hold certain attitudes towards an object by evaluating it. After going through this process, the person then decided whether to hold a favorable or unfavorable view towards it. Indeed, such a positive or negative attitude could further influence the person's intentions to engage in various behaviors with regards to that particular object Zakaria, Solfitri, Daud, and Abidin, (2013).

In addition to the theoretical arguments, there were indeed numerous researches conducted on testing the relationship between attitude and academic achievement. There was a general consensus that attitude could be regarded as a significant predictor of one's academic achievement. Most of these researches illustrated the more positive attitude towards an academic subject, the higher the possibility for him/her to perform well academically.

In a research conducted in the U.S., the researchers studied the relationship between students' attitudes and academic achievement in college mathematics by inviting 218 freshmen to complete a set of questionnaire. The result indicated that students' attitudes were highly correlated with their achievement in college calculus. It was found that attitude had a powerful influence on students' academic achievement, even though most of the studies suggested that there was a positive relationship between attitude and academic achievement, there were other researchers arguing that students' attitude might not be a significant predictor of their academic achievement. Ma & Kishor (2007) argued

that the statement “attitude was a significant predictor of academic achievement” was indeed a paradox, saying that Attitude might not necessarily predict one’s academic achievement as it also depended on different factors, like race, sample selection and sample size. In a study conducted by Novianti (2013), they stated that whether attitude could significantly predict one’s academic achievement depended on a number of variables, particularly the ethnic background and social class.

In all, although there were countless researches studying the relationship between attitude and academic achievement, a unanimous result could not be obtained. Therefore, further investigation is needed to confirm the relationship between attitude and academic achievement.

Zakaria, Solfitri, Daud, and Abidin, (2013) conducted a study comparing the effect of attitude, motivation, and academic engagement on academic performance among eighth graders in the areas of mathematics and science. They used 25 percent of the National Education Longitudinal Study’s student sample from 1988, and analyzed two motivation factors, one academic engagement factor, and one attitude factor. In all cases, their predictions were correct. The study of the total effects revealed the important influences of academic time, attitude, and motivation on achievement. Of primary importance is the evidence of the strong effects of positive attitude, and engagement in academic work for success in mathematics and science (Novianti, 2013).

Zehm and Kottler, (2013) and Butty, (2011) studies shared consensus with regard to the significance of attitudes in predicting achievement. They further complemented the results of earlier studies, with the former proving that the students’ initial attitude towards

school was significantly related to academic performance, while the latter found that attitudes predicted their deep approach to learning.

2.7 Gender Related to Performance in Algebra

Algebra is one of the broad parts of mathematics. Long research history in this area had shown that male advantage in mathematics achievement is a universal phenomenon (Ekanem, 1999). According to Harter, (2002), gender differences in mathematics achievement become apparent at the secondary level when female students begin to exhibit less confidence in their mathematics ability and perform lower than males on problem solving and higher level mathematics tasks. Gallagher and Kaufman (2006) recognized that the mathematics achievement and interest of boys are better than the girls. However they explained that they don't know the main cause of these differences. In a study by Tarim, 2009 it was found that for all the attitudinal variables (anxiety, confidence and motivation), males had higher mean scores than females globally the issue of gender inequality in Science, Technology and Mathematics Education had produced inconclusive results, one meta analysis covering the period 1994 – 2008 on Mathematics and gender led to two conclusions: the average gender gap is very small (statistically insignificant), and the fact that the differences tend to decline with time (Friedman, 1989).Another meta-analysis of 100 studies in gender and Mathematics performance corroborated the above findings (Kiely, 2010). The American Psychology Association (2010) reports that in reality girls around the world are not worse at mathematics than boys even though boys are more confident in their mathematics abilities.

In late elementary school, females outperform males on several verbal skills tasks: verbal reasoning, verbal fluency, comprehension, and understanding logical relations

(Kiely, 2010). Kearney-Cooke, (2010) asserted that on average, girls do better in school than boys, girls get higher grades and complete high school at a higher rate compared to boys. An international aptitude test administered to senior secondary students in 35 countries, for example, showed that females outscored males on reading literacy in every country. Some gender-based science researchers have reported that what both the "feminist empiricists" and the "liberal feminist critics" seem to agree on is that females in principle will produce exactly the same scientific knowledge as males provided that sufficient rigour is undertaken in scientific inquiry (Kimura and Giggs, 2012). They also believe that inequality in science and science education is caused by political, educational and social factors external to science. There is need therefore to give boys and girls exactly the same opportunities and challenges.

Some studies have included a number of factors which could contribute to the emergence of gender differences. One of the factors is said to be from students who believed that Mathematics was a male subject and that boys performed better than girls (Tambawal, 2004). The other factor is believed to be from family influences and socio-economic status of parents, and cultural and traditional influences. Such factors were believed to be significant in the trend toward learning of algebra and could influence girls on subjects and job selections.

In spite of research evidences for male's superiority in mathematics achievement, research findings from Mullis and Martin, (2010) do not support the difference between two genders in mathematics achievement. Alomar, (2016) also find no gender difference on the mathematical reasoning ability at elementary level. Abiam and Odok (2006) found no significant relationship between gender and achievement in number and numeration,

algebraic processes and statistics. They however found the existence of a weak significant relationship in Geometry and Trigonometry.

According to a recent international study conducted by IEA, on average across all countries, there was essentially no difference in achievement between boys and girls at either the eighth or fourth grade (Ekanem, 1999). Cech, (2012) studied United Arab Emirates high school students and found out that females outperformed males in mathematics achievement; while Gallagher and Kaufman, (2010) in a study found that females performed less well than males on geometry and reasoning but females performed as well as males on algorithmic operations oriented items. Koller, Schnabel, and Baumert, (2015) indicated that males outperformed females in mathematics achievement at the junior high and high school levels, there were also significant differences in attitudes toward mathematics between the two groups.

Curricular materials used in the schools, have also been singled out as an influencing factor in the study of Mathematics. For example, in some textbook girls were portrayed as insignificant or invisible as compared to boys who dominated in presentation, and were referred to as pioneers and great scientists (Pajares and Miller, 2014). Furthermore, studying environment where boys and girls study together, in co-education schools had been an issue in current educational debates, some emerging evidence also showed that single - sex school could provide the environment where girls could shine (Markman, 2008).

According to Markman in Psychology Today, girls and boys get different reactions from teachers in mathematics from an early age. When boys have difficulty, teachers are more likely to encourage them to keep trying and tell them that mathematics is simply a

skill that must be acquired. Alternatively, when girls have trouble teachers often express how mathematics is difficult and do not necessarily exude confidence in the girls' capacity to understand the problem. As a result of these differing views, girls see mathematics as a talent, which they can only be successful in for a limited amount of time. Boys are more likely to be motivated to understand mathematics concepts because they see it as a skill, which can be understood only through practice (Markman, 2008). Supporting Markman's stance, Cech, (2012) writes, "Gender researchers have shown that the root of this girl problem is not differences in innate mathematics skills, but rather the contexts in which students learn mathematics-contexts that give girls less encouragement and less confidence in their mathematics abilities". Cech in his work expands by saying that many people have the wrong idea believing that gender gaps in mathematics achievement are because of the girls and not because of teachers', parents', and/or peers' influence on the girls.

2.8 Overview of Similar Studies

Chiu, (2010) compared using the Jigsaw classroom technique with traditional direct instruction in a 12th grade physics class. The study applied the quasi experimental research design with 80 boys and 72 girls as sample. Two instruments were used; Academic Achievement Test and a questionnaire looking at personality variables (goal orientation, self-concept, and uncertainty orientation). The data collected were analysed using ANOVA. The topics (Motion of Electrons and Electromagnetic Oscillations and Waves) were introduced through direct instruction in both conditions. When comparing traditional instruction and the Jigsaw classroom, there was clear difference in the learning experience. Students in the Jigsaw classroom did show higher achievement scores in areas

that they had been assigned. The Jigsaw classroom students had a more favorable view of the learning experience than those in the traditional instruction condition.

A study conducted in Kenya by Novianti, (2013) on effects of the use of Jigsaw Cooperative learning Strategy on students' achievement in mathematics. Solomon four non-equivalent control group research design was used in the study. The two experimental groups received the Jigsaw cooperative learning Strategy as treatment and two control groups were taught using the conventional learning/teaching methods. A simple random sample of four co-education district secondary schools was selected from Laikipia East District. The sample size was 160 students out of a population of about 20,000 students in the district. A mathematics achievement test (MAT) was used for data collection. The instrument was validated and had reliability coefficient of 0.87. Data was analyzed using t-test and ANOVA tests to test hypothesis at 0.05 significance level. The study revealed that learners taught using Jigsaw cooperative learning strategy performed better than those taught using Conventional learning methods. The results also show that there is no significant gender difference in achievement when learners are taught using Jigsaw cooperative learning strategy.

Mohammad et al, (2011) compared Jigsaw I Learning Strategy and Traditional teaching technique. The study used a survey research design with two questionnaires for Jigsaw I Learning Strategy and Traditional teaching technique respectively. The study revealed that Jigsaw I Learning Strategy brings about higher test scores, better interest, and participation in mathematics when compared to Traditional teaching technique.

A number of researchers have demonstrated that there is a significant correlation between attitude and achievement. However it cannot be concluded that positive attitude

always causes high achievement in mathematics. For example, Kiely (2010) showed that on average a small number of pupils who were not good enough in mathematics obtained high scores in the attitude test. Butty, (2011) examined the relationship among the factors students' attitude toward learning mathematics, students' mathematical creativity and students' school grades and their effect on achievement in mathematics. He found out that the best predictor was the students' attitude toward learning mathematics.

Students' attitude towards mathematics is very subjective and varies among the students. Several studies had been conducted to find out the relationship between attitude towards mathematics and academic achievement of the students. Most of these studies showed that there is a positive correlation between students attitude towards mathematics and academic achievement of students (Mohammad, Mahmood, and Ismail, 2011; Bramlett & Herron, 2009; Ma and Kishor, 2007) Studies have also shown that students attitude towards problem solving in terms of patience, confidence and willingness had a positive relation with students" mathematics achievement (Mohammad et al, 2011).

Burstein (1992) in a comparative study of factors influencing mathematics achievement found out that there is a direct link between students' attitudes towards mathematics and student outcomes. Fisher and Rickards, (2013) opined that students' attitudes about the value of learning science may be considered as both an input and outcome variable because their attitudes towards the subject can be related to educational achievement in ways that reinforce higher or lower performance. This means that those students who do well in a subject generally have more positive attitudes towards that subject and those who have more positive attitudes towards a subject tend to perform better in that subject. Vermeer, Boekaerts, and Seegers, (2013) argues that negative

attitudes towards mathematics play a role in determining our thoughts, memory, learning process and behavior in the course of learning the subject.

Novianti, (2013) conducted a study comparing the effect of attitude and motivation on academic performance among eighth graders in the areas of mathematics and science. It revealed the important influences of attitude and motivation on achievement. Of primary importance is the evidence of the strong effects of positive attitude in academic work for success in mathematics and science.

Alomar, (2016) have reported that although there is a relation between attitude and achievement, this relation should not be considered definite. He therefore concluded that, being merely aware of an individual's attitude towards a subject is a week predictor of his subsequent performance.

There are conflicting views concerning success in mathematics based on gender. Females are closing the gap in mathematics scores (Cech, 2012). Although gender is not the primary factor determining students' success in mathematics, it can however, affect how students are treated in the classroom, as well as their self-confidence. According to Art Markman in Psychology Today, girls and boys get different reactions from teachers in math from an early age. When boys have difficulty, teachers are more likely to encourage them to keep trying and tell them that math is simply a skill that must be acquired. Alternatively, when girls have trouble teachers often express how math is difficult and do not necessarily exude confidence in the girls' capacity to understand the problem. As a result of these differing views, girls see math as a talent, which they can only be successful in for a limited amount of time. Boys are more likely to be motivated to understand math concepts because they see it as a skill, which can be understood only

through practice (Markman, 2008). Supporting Markman's stance, Erin Cech, (2012) writes, "Gender researchers have shown that the root of this girl problem is not differences in innate math skills, but rather the contexts in which students learn math-contexts that give girls less encouragement and less confidence in their math abilities".

Despite such consistent findings of girls' negative attitude towards mathematics, studies of classroom environment have shown that the girls' attitude towards mathematics improved greatly in classes which actively involved girls in the learning of mathematics. Boaler, (2008) investigated the impact of cooperative learning on sixth grade girls. The results showed that girls had more positive attitudes towards mathematics when it was taught in cooperative settings. in his study girls would enjoy mathematics, increase their time on math tasks, and have positive emotional reactions to math if math were taught in a cooperative setting.

Swetman, (2005) conducted a research comparing students' attitude, gender and academic achievement in mathematics. From this study, it was concluded that, as far as differences in attitude development are concerned, girls' positive attitudes towards mathematics decline as they grow older. Initially girls have more positive attitudes towards mathematics than boys, but as they continue in school, girls' attitudes become more negative. He recommended that, in order to improve girls' performance in mathematics, teachers need to facilitate positive attitude in girls towards mathematics.

2.9 Implications of Literature Reviewed on the Present Study

From the above literature reviewed, studies have shown that teaching methodology play a significant role in students' academic achievement. Teaching methods where students are able to work in a team in order to discuss mathematical problems seem to

have a positive effect on students' conceptual understanding, strategic competence and adaptive reasoning. The main implication of this study provided the empirical evidences to show that the students learning in jigsaw learning setting did had some impact on students' performance in mathematics in terms of their understanding and applicability and students were able to integrate their learnt concepts to construct knowledge. Moreover, through the process of team work, they shared their opinions and learned from each other, thus they enjoyed more during the expert group interaction. It had also been established that attitude played a vital role in the teaching and learning process. Attitude of students towards mathematics in general had been discovered to be directly proportional to their academic performance by most of previous studies.

Teachers should be aware therefore, that the method of teaching they employ has a direct impact on the students' attitude which is in turn directly proportional to the students' achievement in the concepts taught. Teachers should also note that while repeated success establishes a strong sense of confidence, the occasional failure is not likely to impact much upon one's attitude towards the concepts.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

A major problem facing Nigerian secondary schools is the poor performance of students in core subjects, especially mathematics. Without a credit in mathematics the student can not pursue most science and technology courses at institutions of higher learning in Nigeria, as such, Nigeria‘s quest for technological advancement and economic emancipation is being undermined by the continued poor mathematics achievement of senior secondary school students in external examinations. This chapter therefore, presented a detailed description of the procedure of the investigation into the stated problem. The methods and steps followed in carrying out this study were presented under the following sub-headings:

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Technique

3.5 Instrumentation

3.5.1 Validity of the Instruments

3.6 Pilot Study

3.6.1 Reliability of the Instruments

3.7 Procedure for Data Collection

3.8 Procedure for Data Analysis

3.02 Research Design

The research design adopted for this study was quasi-experimental research design. Quasi experimental was adopted as it is impossible to have total control on the study sample. The design comprised of two groups; experimental and control groups. Both groups were pre-tested before the treatment. This was to ensure homogeneity among the students. The experimental group was subjected to the treatment (Jigsaw I Learning Strategy) while the control group was taught using the conventional lecture method. After the treatment, posttest was also administered to both groups to determine their level of achievement and possible change in attitude. Figure 3.1 shows the illustration of the design.

EG ⟶ **O_{11}** ⟶ **O_{12}** ⟶ **X_1** ⟶ **O_{21}** ⟶ **O_{22}**

CG ⟶ **O_{11}** ⟶ **O_{12}** ⟶ **X_0** ⟶ **O_{21}** ⟶ **O_{22}**

Figure 3.1: Diagram of Research Design

Where

EG = Experimental Group

CG = Control Group

O_{11} = Pretest for Performance in Algebra.

O_{12} = Pretest for Attitude Towards Algebra.

O_{21} = Posttest for Performance in Algebra

O_{22} = Posttest for Attitude Towards Algebra

X_1 = Use of Jigsaw I Learning Strategy

X_0 = Conventional Method

3.03 Population of the Study

The target population for this study comprised of all the 10 single-sexed senior secondary school students in Zaria Educational Zone. This was made up of 5 male schools and 5 female schools with a total of 1,757 students with average age of 16 years, of which 950 students were male while 807 students were female. SS2 students were used for this study, because they are the most suitable class in senior secondary schools. Summary of the population is shown in Table 3.1.

Table 3.1: Population of the Study

S/no	School	Male	Female	Total
1	GSS Zaria	150	-	150
2	Barewa College Zaria	230	-	230
3	GGSS Zaria	-	135	135
4	GGSS Dogon Bauchi	-	215	215
5	GGSS K/Gayan	-	158	158
6	GGS Pada	-	189	189
7	GSS Chindit	216	-	216
8	GGSS Chindit	-	110	110
9	Alhudahuda College Zaria	203	-	203
10	SSS Kufena Zaria	151	-	151
	Total	**960**	**807**	**1,757**

Source: (Zaria Education Zone, 2015)

3.04 Sample and Sampling Technique

In order to ensure that each school had an equal chance of being chosen, a random

sampling technique (ballot method) was used to select four senior secondary schools from a total of 10 schools. The selected schools were: Barewa College Zaria with 230 SS2 students, across 3 arms, GGSS Zaria with 135 SS2 students across 2 arms, GSS Chindit with 216 SS2 students across 3 arms and GGSS Chindit female with 110 SS2 students across 2 arms. A simple random sampling technique (ballot method) was used to select one SS2 intact-class in each school. The total sample size was 234 students, which was in accordance with Krejcie and Morgan (1971) Table for determination of sample size for a given population. GSS Chindit male and GGSS Chindit female were purposively selected as experimental group while Barewa College Zaria and GGSS Zaria constitute the control group. This was intended to avoid interaction between the groups. The control group was made up of 119 students while 115 students made experimental group.

Table 3.2: Sample of the Study

S/N	Group	Male	Female	Total
1	Experimental	-	53	53
2	Experimental	62	-	62
3	Control	-	65	65
4	Control	54	-	54
	Total	**116**	**118**	**234**

3.05 Instrumentation

Three research instruments were used in the course of this research. They were:

1. Pre-Algebra Achievement Test (PAAT)
2. Algebra Achievement Test, (AAT) for post test
3. Students Attitude Assessment Scale (SAAS)

Pre Algebra Achievement Test (PAAT) pretest

Pre-Algebra Achievement Test (PAAT) pretest consisted of 50 items in 4 multiple choice algebra questions. The contents of PAAT were extracted from senior secondary school one syllabus. PAAT had two sections; section A captured respondent's bio data such as gender and age while section B contained questions on algebra. The items in PAAT measured students' ability in the area of knowledge, understanding and application of algebra.

Algebra Achievement Test (AAT) post-test

Algebra Achievement Test (AAT) pretest consisted of 50 items in 4 multiple choice algebra questions. Algebra Achievement Test had two sections; section A captured respondent's bio data such as school of respondent, class, gender and age while section B contained questions on algebra. The content of AAT were extracted from WAEC past questions from the year 2005 to 2014. The items in AAT measured students' ability in the area of knowledge, understanding and application of algebra.

Students Attitude Assessment Scale (SAAS)

Students Attitude Assessment Scale was adapted and modified from Martha-Tapia (1996) Attitude Scale to suit the present study. Students Attitude Assessment Scale has two sections; section A captured respondent's bio data such as school of respondent, class,

gender and age while section B consists of 30 items about students' attitude towards algebra. SAAS consisted of 30 statements about students' attitude towards algebra; in the form of 5 points Likert scale with Strongly Agree (SA), Agree (A), Undecided (UD), Disagree (DA) and Strongly Disagree (SD) as respond codes. SAAS was administered to both groups before and after the treatment. It measured attitudinal change towards algebra before and after the treatment. (See appendix A).

3.5.1 Validity of the Instruments

The instruments were subjected to face and content validity by two experts in Mathematics Education Department from Ahmadu Bello University, Zaria who also happened to be the supervisors of this research work. Another senior lecturer from Department of Mathematics, Federal College of Education, Zaria also validated the instruments. These experts' observations and criticisms were incorporated into the test items. These observations included inappropriate timing, ambiguous statements, and poor alignment of items and labeling of diagrams.

3.6 Pilot Study

A pilot-test was conducted at two senior secondary schools namely: Alhudahuda College Zaria and GGSS Dogon Bauchi, which are not part of the study sample but belong to the population of the study. Fifty students (25 male from Alhudahuda College Zaria and 25 female students from Dogon Bauchi) were used for the study. The Algebra Achievement Test (AAT) and Students Attitude Assessment Scale (SAAS) were administered. It took the respondents an average time of one hour on AAT and an average time of 20 minutes to complete SAAS. This helped in the appropriate timing in the actual study. The scores obtained from the pilot test enhanced the determination of the reliability

of the instruments as follows; Result of PAAT showed that a reliability coefficient (r) = 0.8, Facility Index (F.I) = 60% and Discriminating Index (D.I) = 0.60. The result of AAT showed a reliability coefficient (r) = 0.79, Facility Index = 50% and Discriminating Index = 0.7 while SAAS showed a reliability coefficient (r) = 0.85. (see Appendix H)

3.6.1 Reliability of the Instruments

Reliability of an instrument is the consistency of an instrument over time. Scores obtained from the pilot test were analyzed using Cronbach's Alpha formula to obtain the reliability coefficients of 0.79 for AAT while for SAAS, it was 0.85 using the PPMC. Therefore, the instruments were satisfactorily reliable and considered good for the research.

3.7 Procedure for Data Collection

PAAT was administered by the researcher to both experimental and control groups, to ensure that the subjects were homogenous at entry level. SAAS was also administered to both groups to find out their initial attitude towards algebra. The experimental group was taught algebra using Jigsaw I Learning Strategy, while the control group was taught the same concept using lecture method. The treatment lasted for 7 weeks. AAT and SAAS were then administered to both control and experimental groups as posttest, this was to examine the added value in students' learning experience, due to the type of instruction they were exposed to, and to measure students' attitudinal change towards algebra and mathematic in general respectively.

3.8 Procedure for Data Analysis

The data collected for this study were to answer the research questions in section 1.4 of chapter one and to also test the hypotheses stated in section 1.5 of chapter one. A significance level of 0.05 was set for retaining or rejecting the stated hypothesis.

The research questions were:

1. How does Jigsaw I Learning Strategy influence students' mean performance in algebrain senior secondary schools in Zaria metropolis?
2. How does Jigsaw I Learning Strategy influence students' attitude towards algebra in senior secondary schools in Zaria metropolis?
3. Is there any significant difference between the mean performance score of male and female students taught algebra using Jigsaw I Learning Strategy?

The stated hypotheses were

H_{01}: There is no significant difference between the performance of students taught algebrausing Jigsaw I Learning Strategy and that of those taught using conventional lecture method.

Using the Algebra Achievement Test post-test scores for experimental and control groups, the Independent t-test statistic was used to test for any significant difference between the mean score of students taught algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method, at 0.05 level of significance

$H_{02:}$ There is no significant difference between the attitudes of students taught algebra using Jigsaw I Learning Strategy and those taught by lecture method.

Using Students Attitude Assessment Scale post-test scores for experimental and control groups, the Mann-Whitney test statistic was used to test for any significant

difference in students' attitude towards algebra after being exposed to Jigsaw I Learning Strategy at 0.05 level of significance.

H_{03}: There is no significant difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy.

Using the Algebra Achievement Test post-test scores of experimental and control groups for male and female, the Independent t-test statistic was used to test for any significant difference between the performance score of male and female students taught algebra using Jigsaw I Learning Strategy.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This research sought to find the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students. Three research hypotheses corresponding to the research questions and objectives of the study were stated and tested at $p < 0.05$ level of significance. Hypothesis 1 stated that there is no significant difference between the mean performance of students taught algebra using Jigsaw I Learning Strategy and those taught using lecture method. Hypothesis 2 stated that there is no significant difference between the attitude of students taught algebra using Jigsaw I Learning Strategy and that of those taught by lecture method. While hypothesis 3 stated that there is no significant difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy. Quasi-experimental research design was adopted for the study. The design comprised of experimental and control groups. Both groups were pre-tested using the instrument PAAT to ensure homogeneity among the students at entry level. The experimental group was taught using Jigsaw Learning Strategy while the control group was taught using lecture method. After the treatment, AAT and SAAS were administered to both groups to determine their level of achievement and possible change of Attitude towards Algebra. The sample size for the study was 234 SS2 students with an average age of 16 years. The data collected were analyzed using SPSS and the results were presented according to the research questions and hypotheses that guided the study. The level of significance adopted for rejecting or

retaining the stated hypotheses was at $p < 0.05$ level of significance. The procedure was presented under the following headings:

4.2 Data Presentation

4.3 Analysis

4.4 Discussions

4.5 Summary of Findings

4.2 Data Presentation

This section presented the result and interpretation of data collected from the study subjects.

Table 4.1: Descriptive Statistics on performances between Experimental and Control Groups

Group	N	Mean($\bar{X}$)	SD	Mean Difference
Experimental Group	115	45.81	17.707	10.35
Control Group	119	35.46	13.451	

Table 4.1 presented the mean and standard deviation of the performance scores of the experimental and control groups. The experimental group had a higher mean score and standard deviation of 45.81 and 17.707 respectively while control group had mean score and standard deviation score of 35.46 and 13.451 respectively. This indicated that Jigsaw I Learning Strategy had positive effect on students' performance in algebra in senior secondary schools in Zaria Educational Zone.

Table 4.2: Descriptive Statistics for Attitude between experimental and Control Groups

Groups	N	Mean Rank	Sum of Ranks
Experimental	115	165.23	19002.00
Control	119	71.37	8493.00

Table 4.2 showed Mean Rank and Sum of Ranks of experimental and control groups. The Experimental Group had Mean Rank of 165.23 and Sum of Ranks of 19002.00 respectively, while control group had a Mean Rank of 71.37 and Sum of Ranks of 8493.00. These indicated that there was a mean Rank difference of 93.86 in favour of the experimental group. These therefore implied that the experimental group showed more positive attitude towards algebra.

Table 4.3: Descriptive statistics on Performance by gender in Experimental Group

Group	N	Mean($\bar{X}$)	SD	Mean Difference
Female	53	42.42	17.081	6.29
Male	62	48.71	17.852	

From Table 4.3 the male showed a higher mean score of 51.50 while the female had a mean score of 50.75, showing a mean difference of 0.75. These indicated that the male students had a slightly higher mean score when Jigsaw I Learning Strategy was used as the instructional method.

4.3 Analyses

The following hypotheses were formulated for testing at $p < 0.05$ level of significance.

Hypothesis 1

There is no significant difference between the mean performance of students taught algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method.

To test this hypothesis, the scores obtained from Algebra Achievement Test of the experimental and control groups were subjected to the independent t-test statistics at $p < 0.05$ level of significance as shown in Table 4.4

Table 4.4: t-test analysis on performance between Experimental and Control Groups

Groups	N	Mean	SD	Df	t-cal	t-crit	p-value	Remark
Experimental	115	45.810	17.707					
				232	5.044	1.960	0.001*	Reject H_{01}
Control	119	35.460	13.451					

* Significant, $p < 0.05$

Table 4.4 indicated that a t-value of 14.11 with a corresponding p-value of p=0.001. It was observed that p-value was less than the level of significance; hence, the hypothesis was therefore rejected. This implied that there was significant difference between the performance of students taught Algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method.

Hypothesis 2

There is no significant difference between the average attitude of students taught algebra using Jigsaw I Learning Strategy and those taught by lecture method.

To test this hypothesis, the mean scores obtained from Students Attitude Assessment Scale of experimental and control groups were subjected to Mann-Whitney test statistic. The summary of the analysis is shown in Table 4.5

Table 4.5: Mann-Whitney test for attitude between Experimental and Control group.

Group	N	Mean Rank	Sum of Ranks	df	u-cal	u-crit	p-value	Decision
Experimental	115	165.230	19002.000					
				233	1353.000	124.340	0.001*	Reject H_{02}
Control	119	71.370	8493.000					

*significant, $p < 0.05$

Table 4.5 has shown a significant difference between the average attitudes of students taught algebra using Jigsaw I Learning Strategy and that of those taught by lecture method. This followed from the p-value of 0.001 at 233 degrees of freedom, which was less than p-value of 0.05 level of significance. Therefore, the statistical hypothesis was rejected.

Hypothesis 3

There is no significant difference between the mean performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy.

To test this hypothesis, data generated from Algebra Achievement Test of male and female of the Experimental Group were compared using the independent t-test statistic, as shown in Table 4.6

Table 4.6: t-test analysis on Performance by Gender in Experimental Group.

Group	N	Mean	SD	Df	t-cal	t-crit	p-value	Remark
Female	53	42.42	17.081					
				113	-1.923	1.960	0.887*	Retain H_{03}
Male	62	48.71	17.852					

*Not significant, $p > 0.05$

From Table 4.6 a p-value of 0.887 at 113 degree of freedom was observed with α=0.05 and a critical t-value of 1.960. Since p-value is greater than stated 0.05 level of significance, it was evident that there was no significant difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy. Therefore, the hypothesis was retained.

4.4 Discussions

The study investigated the impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria metropolis, Kaduna state, Nigeria. Five topics namely Algebraic Fractions, Simultaneous Equation, Quadratic Equation, Arithmetic Progression and Geometric Progression were examined in the study. The experimental group was taught algebra using Jigsaw I Learning Strategy while the control group was taught using the lecture method. Both experimental and control group were pretested and post tested in order to ascertain homogeneity and level of achievement among the students respectively. Therefore, the differences observed were due to the treatment.

The students taught algebra using Jigsaw I Learning Strategy performed better and had higher mean and standard deviation scores of 45.81 and 17.707 respectively, than those taught using lecture method with mean and standard deviation scores of 48.71 and

17.852 respectively. This implied that the use of Jigsaw I Learning Strategy improved students' performance in algebra. This result was in agreement with the findings of Novianti, (2013) on effects of the use of Jigsaw Cooperative learning Strategy on students' achievement in mathematics. Carried out in Kenya. Solomon four non-equivalent control group research design was adopted for the study. The experimental group received the Jigsaw cooperative learning Strategy as treatment while control group was taught using the conventional teaching method. The sample size was 160 students out of a population of about 20,000 students. A Mathematics Achievement Test (MAT) was used for data collection. The instrument was validated and had reliability coefficient of 0.87. Data was analyzed using t-test at 0.05 significance level. The study revealed that learners in the experimental group performed better than those in the control group. The findings of Hanze and Berger (2007) and Hargreaves and Pell (2009) also agree with the findings of this research work.

Hypothesis two revealed a significant difference between the attitudes of students taught algebra using Jigsaw I Learning Strategy and those taught by lecture method. The students in the experimental group showed more positive attitude towards algebra than those of the control group. The difference between the two groups was likely due to the treatment. This indicated that, the use of Jigsaw I Learning Strategy in teaching algebra enhanced the students' attitude toward algebra. This is in-line with the findings of Novianti, (2013) who conducted a study comparing the effect of attitude and motivation on academic performance in mathematics and science. The research applied a survey research design with 240 male and female students as study sample. He adapted Martha Tapia (1996) Attitude Scale. It revealed the important influences of attitude and

motivation on achievement. Of primary importance is the evidence of the strong effect of positive attitude on academic work for success in mathematics and science. The similarity between the findings could be based on the fact that both researches adapted the same instrument. Also, the findings of Shachar and Sharan (1994), Johnson (2009), Esmonde (2009) and Galton, Hargreaves and Pell (2009) are also in agreement with the findings of this research.

The result obtained from the analysis of hypothesis three revealed that male students had a slightly higher mean of 48.71, and a standard deviation of 17.852 while their female counterpart had a mean of 42.42 and a standard deviation of 17.081. Table 4.6 revealed that the observed difference was not significant. This finding is in line with the findings of Abiam and Odok (2006) titled "Mathematics Achievement and Gender Difference in Senior Secondary Schools in South-South Nigeria". The study applied a quasi-experimental research design with 62 male students and 74 female students as sample. Mathematics Achievement Test was used to collect data, which were analyzed using t-test statistic. They found difference which was not significant between the performance of male and female students. Similarly, the findings of Mullis and Martin (2010) and Alomar (2016) are also in agreement with the findings of this research work. This agreement could be as a result similarity in the characteristics of the study sample, as they have all used SS2 students to conduct the study. They have also employed t-test for their analysis.

4.5 Summary of Findings

In this study, the following findings were made:

1. There was difference between the performance of students taught Algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method. The students taught Algebra using Jigsaw I Learning Strategy performed better than the students taught Algebra using the Lecture Method. This indicated that JSILS improves students' Performance in Algebra.
2. There was difference between the attitudes of students taught algebra using Jigsaw I Learning Strategy than those taught by lecture method. It was evident that students taught Algebra using Jigsaw I Learning Strategy developed a more positive attitude towards algebra than those taught using conventional lecture method. Therefore, Jigsaw I Learning Strategy helped students to improve their Attitude towards Algebra.
3. There was no much difference between the performance of male and those of the female students taught algebra using Jigsaw I Learning Strategy. This indicated that Jigsaw Learning Strategy in not gender bias.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study determined the impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria Education Zone. This chapter summarized this research work and is presented under the following headings:

5.2 Summary of the Study

5.3 Conclusion

5.4 Contributions to knowledge

5.5 Recommendations

5.6 Limitations of the study

5.7 Suggestions for Further Studies

5.2 Summary of the Study

The study investigated the Impact of Jigsaw I Learning Strategy on Attitude and Performance in Algebra among Senior Secondary Schools Students in Zaria Education Zone. The main variables investigated were Attitude, Performance and Jigsaw I Learning Strategy. The population of the study consisted of all the 10 single-sexed senior secondary school students in Zaria Education Zone. This was made up of 5 male schools and 5 female schools with a total of 1,757 students, of which 950 students were male while 807 students were female.

A simple random sampling technique (ballot method) was used to select four senior secondary schools from a total of 10 schools. The selected schools were: Barewa

College Zaria, GGSS Zaria, GSS Chindit male and GGSS Chindit female. A simple random sampling technique (ballot method) was used to select one SS2 class in each school. Bringing the total sample size to 234 students. The control group was made up of 119 students while 115 students made the experimental group.

The instruments used for the study were Students Attitude Assessment Scale (SAAS), Pre-Algebra Achievement Test (PAAT) and Algebra Achievement Test (AAT). SAAS was adapted and modified from Martha-Tapia (1996) attitude scale to suit this study. SAAS consisted of 30 statements about students' attitude towards algebra. PAAT and AAT each consisted of 50 items, 4 multiple choice questions on algebra. The items were extracted from SS1 mathematics syllabus and WAEC past questions from the year 2005 to 2014 respectively.

The result of the analysis of data was summarized as follows:

It was established that there was a remarkable difference between the performance of students taught Algebra using Jigsaw I Learning Strategy and those taught using conventional lecture method in favour of the group that was taught using Jigsaw I Learning Strategy. Hence, Jigsaw I Learning Strategy was more effective in improving students' performance in algebra.

Students taught algebra using Jigsaw I Learning Strategy developed more positive attitude towards algebra than those that were taught using lecture method. This implied that JSILS was more effective in improving students' attitude towards algebra.

Male students taught using Jigsaw I Learning Strategy performed slightly better than their female counterpart when compared. Though, the difference is negligible. This revealed that JSILS is gender friendly and not gender bias.

It was recommended that Jigsaw I Learning Strategy should be used in teaching algebra and mathematics in general in senior secondary schools. It was also recommended that professional bodies like Mathematics Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN), and research centers like Nigerian Educational and Research Development Council (NERDC) should incorporate Jigsaw I Learning Strategy in the science curriculum at every level of learning to encourage the use of Jigsaw I Learning Strategy in schools especially at primary and secondary schools. It was suggested that further studies should be carried out in other areas of mathematics, in mixed-sex schools, in other states in the Federation and also in our tertiary institutions to ascertain if similar findings hold.

5.3 Conclusions

Based on the findings of the study, the following conclusions were made;

1. Jigsaw I Learning Strategy is a system of learning that can improve the performance of students in Algebra, if properly implemented. This is evident in the findings on hypothesis one. Students taught algebra performed better than those taught using conventional lecture method.
2. Students' attitude towards algebra can be improved when Jigsaw I Learning Strategy is used as a medium of instruction. This deduction is made because students taught algebra using Jigsaw I Learning Strategy developed more positive attitude towards algebra than those taught by lecture method.
3. Male students taught algebra using Jigsaw I Learning Strategy did not differ significantly from their female counterpart taught algebra using Jigsaw I Learning

Strategy. As such, Jigsaw I Learning Strategy has as much positive impact on male students' performance in algebra as much as it has on the female students.

5.4 Contributions to knowledge

Based on the findings of the studies, mathematics students can be made to learn effectively irrespective of gender related differences, as it had been established that Jigsaw I Learning Strategy is gender friendly. It had also been established that Jigsaw I Learning Strategy foster positive attitude towards learning mathematics concepts, especially algebra. As such Jigsaw I Learning Strategy should be encouraged among students to help them develop the required attitude.

Finally, the Impact of Jigsaw I Learning Strategy on Students' Performance has been proven to be positive. It was discovered that Jigsaw I Learning Strategy had significantly improved students' performance in algebra.

5.5 Recommendations

The following recommendations were made base on the findings:

1. The use of Jigsaw I Learning Strategy should used by mathematics teachers in teaching algebra in senior secondary schools.
2. Jigsaw I Learning Strategy is gender friendly, as such; teachers should use it freely to teach both male and female students.
3. Seminars and workshops should be organized by heads of schools so as to train mathematics teachers on the use of Jigsaw I Learning Strategy in mathematics classrooms.
4. Professional bodies like Mathematics Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) and research centers like Nigerian

Educational and Research Development Council (NERDC) should incorporate Jigsaw I Learning Strategy in the science curriculum at every level of learning to encourage the use of Jigsaw I Learning Strategy in schools especially at primary and secondary schools.

5.6 Limitation of the study

The major limitation of this research was the period allocated for mathematics in secondary schools time-table. Mathematics usually was the first period every morning, as such giving room for late comers to miss out on some key lessons or even miss the lesson completely in some cases. This has impact on the final outcome of the research.

5.7 Suggestions for Further Studies

1. Similar studies can be conducted in other areas of mathematics such as geometry, trigonometry, statistics, etc and also in the junior secondary school level.
2. Similar studies can be carried out in the junior secondary schools in Zaria Education Zone to see if the result will remain or change.
3. Similar research can be carried out among students of mixed-sex students to ascertain if similar findings hold.

References

Abiam, P. O. &Odok, J. K. (2013). Factors in students' achievement in different branches of secondary school mathematics. *Journal of Education and Technology 1(1),* 161-168.

Adenuga, R.A., Owoyele, J.W., Adenuga, F.T. (2011), Gender and Socio-Economic background differentials in students' attitude to information and communication technologyeducational in Nigerian secondary schools: Implications for policy, ICT Education and Counseling.*International Journal of Psychology and Counseling*, 3(9): 162-166.

Alomar, B. O. (2016). Personal and family paths to pupil achievement, *Social behavioand personality. 34(8), 907 – 922.*

Aronson, E., (2000) "*The Jigsaw Classroom*." Beverly Hills, CA: Sage Publications.

Boaler, J. (2008) Students' experiences of ability grouping – disaffection, polarization and theconstruction of failure. *British Educational Research Journal* 26(5): 631-648.

Bolaji, C. 2005: A study of factors influencing students‟ attitude towards mathematics in the Junior Secondary Schools; Mathematics teaching in Nigeria. Retrieved on Oct. 2011 from http://www2.ncsu.edu/ncsu/aern/bolajim.html

Bramlett, D. C. & Herron, S. (2009). A study of African-American College students' attitudetowards mathematics. *Journal of Mathematical Sciences & Mathematics Education, 4*(2),43-51

Brown, H., & Ciuffetelli, D.C. (2009). *Foundational methods: Understanding teaching and learning*, 507. Toronto: Pearson Education.

Brush, T., (2007). *The effects of environment on student achievement and attitudes when using integratedlearning system with cooperative pairs*. Educ. Tech. Res. Dev., 45: 51-64. DOI: 10.1007/ BF02299612.

Bukunola, S. &Idowu, J. (2012). *Strength in numbers: Collaborative learning in secondary mathematics*.National Council of Teachers of Mathematics.

Butty,J.A.M (2011). Teacher instruction, Student attitudes and mathematics performance among 10 and 12 grade black and Hispanic students. *Journal of Negro education*, 70 , (1/2) 19-37.

Cech, E. (2012). *Sugar and spice and math under achievement* www.gender.stanford.edu/news/2012/sugar-and-spice.

Chiu, M. M. (2010). Flowing toward correct contributions during groups' mathematics problem solving: A statistical discourse analysis. *Journal of the Learning Sciences,* 17 (3), 415-463.

David, M.., & Roger, O. (2001). *Use of peer tutoring, cooperative learning, and collaborative learning*: Implications for reducing anti-social behavior of schooling adolescents. *US China Education Review, A 11*, 932-945.

Davidson, J. (2005). *Effects of Cooperative Learning on Performance, Attitude, and Group Behaviours in a Technical Team Environmen*t. *ETR&D, 43*(3), 61-71.

Dean, J. (2012). "*Investigating the relationship between mental imagingand mathematical problem solving*". Proceedings of the international conference of Mathematics Education into the 21st century project September *2003.* Ed. Brno. Czech Republic. 62-67.

Denwigwe, C.P. &Ikeotuonye, A.I. (2008). *Sex Differences in General Self- esteem Levels ofSecondary School Students in Abuja Metropolis*.

Ding, C. S., Song, K. &Richardson ,L. I. (2013). Do mathematical gender differences continue? *Educational study, 279 – 295.*

Doğru, E. (2012). *MatematikÖğretimindeKullanılanAyrılıpBirlesmeTekniğinin Öğrencilerin Özyeterlilik, KaygıveKalıcılıkDüzeylerineEtkisi*. taken from website https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp.

Efklides, A., Demetriou, A., &Gustafsson, J.-E. (1992). *Training, cognitive change, and individual differences*. In Demetriou, M. Shayer, & A. Efklides(1990) Modern theories of cognitive development go to school. London: Routledge.

Ekanem, A.U. (1999). *Gender Orientation and Occupational Competence of Workers*. TheCounsellor. 17(1)

Fisher, D. and Rickards, T. (2013) Associations between teacher-student interpersonal behavior and student attitude towards mathematics. *Mathematics Education Research Journal, 10(1),* 3-15.

Gallagher, A.M. & Kaufman, J. C. (2010). Gender differences in mathematics: an integrativepsychological approach. 54(2); 245- 247.

Gillies, R., Ashman, A. &Terwel, J. (2008). The Teacher's Role in Implementing Cooperative Learning in the Classroom. Computer Supported Collaborative Learning Series. Vol. 8, 2008, New York: Springer. Hardcover ISBN: 978-0-387 70891-1

Harter, S. (2002). The Perceived Competence Scale for children. *Child Development.* 53, 87-97.

Heeden,T. (2013). The reverse jigsaw: A process of cooperative learning and discussion. *Teaching Sociology* 31(3), 325-332.

Henderson, W. David, W. (2008). "*Geometric Solutions of Quadratic and Cubic Equations*".Mathematics Department, Cornell University.

Hergovich, A., Sirsch, U. &Felinger M. (2004). Gender Differences in the Self-conceptof Pre-adolescent Children. *School Psychology International* 25(2), 207-222.

Igbokwe, D. I. (2010). Teacher performance in categories of mathematics questions failed by primaryschool pupils. *Abacus*, 24 (1), 9 - 19

Johnson, D. W. (2009). *Reaching out: Interpersonal effectiveness and self-actualization.* (10th ed.).Boston: Allyn & Bacon. http://dx.doi.org/10.1037/0003066X.58.11.934

Johnson, D. W. & Johnson, F. (2006). *Joining Together: Group Theory and group skills* (7th ed.). Boston.

Kagan, S. (1994). "Cooperative Learning and Sociological Factor in Schooling" Kagan Publishing.

Kearney-Cooke, A. (2010). Gender Differences in Self-esteem. *Journal of Gender Specific Medicine.* 2(3): 46-52.

Kiamanesh, A. R , (2014). Factor affecting Iranian students' achievement in mathematics. Cyprus University, Nicosia, 157-169. Available online at http://www.ieadpc. org/download/ieahq/IRC2004/kiamanesh.pdf

Kiely, J. H. (2010). *Success and failure in mathematics among standard sevens in the Bafokengregion,* Unpublished PhD Dissertation, University of Witwatersrand, Johannesburg, South Africa.

Killen, R. (2007). *Effective Teaching Strategies: Lessons from Research and Practice* (4th ed.).

Kimura, D. &Giggs, S. (2012). Sex differences in the brain.Scientific American Special Ed 12: 32- 37.

Klem, M. & Connell, P.J. (2014). Relationships Matter: Linking teacher support to student engagement and achievement. *Journal of School Health*. 74 (7), 262-273.

Köğce, D., Yıldız, C., Aydın, M. &Altındağ, R., (2009). Examining Elementary School Students‟ Attitudes towards Mathematics in Terms of Some Variables, *Procedia Social and Behavioral Sciences, 1*(1), 291-295.

Kolawole, E.(2010). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in mathematics. *Educational research and design*, 3(2), 33-37.

Koller,O., Schnabel, K., &Baumert,J.(2015).The Impact of academic self- concept of ability onthe development of interests during adolescence. *Paper presented at the annual meeting of theAmerican educational research association, San Diego, California*

Krejcie, R.V. & Morgan S.W. (1971). Determining sample size for research activities, educational and psychological measurement, 30:607-610

Li, Y. (2011). "A comparison of problems that follow selected content presentations in Americanand Chinese Mathematics textbooks" *Journal for Research in Mathematics Education.31, 2, 234-241*.

Linn, M.C. & Hyde, J.S. (2009). Gender, Mathematics and Science. *Educational Research.*18:17-19, 22-27. Stanford, C.A. Stanford University Press. London, Sage.

Ma, K. &Kishor, N. (2007). Assessing the Relationship Between Attitude Toward Mathematics and ability-grouping practices on student progress in mathematics." *British Educational Research Journal* 30(2): 279-294.

Macharia, M., Githua, M. Mboroki, M. (2019). Experience of cooperative learning in engineering. *European Journal of Engineering Education, 36*(1), 13-19. http://dx.doi.org/10.1080/03043797.2010.518232

Markman, A. (2008). *Why girls drop math 1: Beliefs about math.* Retrieved July 2012, from Psychology Today: www.psychologytoday.com/blog/ulteriormotives/ 200808/why-girls drop-math-i-beliefs-about-math

McMahon, M. (2007). Social Constructivism and the World Wide Web - A Paradigm for Learning. Paper presented at the ASCILITE conference. Perth, Australia.

Mohammad, N., Mahmood, T. F, & Ismail, M. N. (2011). Factors that influence students in mathematics achievement. *International Journal of Academic Research, 3*(3), 49-54.

Mullis, I. V., Martin, M. O., (2010). Sex differences in objective test performance. *British Journal of Educational Psychology*, *52*, 213–219.

National Assembly of the Socialist Republic of Vietnam [NASRV] (2008). Education Law, No.38/2008/QH11. Hanoi: Education Press.

Novianti, I. (2013). The Application of Cooperative Learning Model-Jigsaw Type in Learning Mathematics. *Asian Journal of Education and e-Learning, 1* (5), 306-310.

Norton, S.J. &Rennie, J. (2010). Students attitude towards mathematics in single-sex and Co-educational schools. *Mathematics Educational Research Journal, 10(1),* 16-36.

Nwoji, Q. J. R. (2009). Evaluating the use of learning resources for primary science education:implication for the learner. *STAN Annual Conference Proceedings,* 245 - 249.

Opolot-Okurot, C. (2005). Student attitudes toward mathematics in Uganda Secondary Schools *African Journalof Research in Mathematics, Science and Technology Education*, 9 (2), 167-174.

Oral B. (2000) "SosyalBilgilerDersindeişbirlikliÖğrenmeileKümeÇalışması Yöntemlerinin ÖğrencilerinErişileri, DerseYönelikTutumlarıveÖğrenilenlerin KalıcılığıÜzerindeki Etkileri", *Ç.Ü. EğitimFakültesiDergisi*, 2(19), 43-49.

Pajares, F., & Miller, M. D. (2014). The role of self-efficacy and self-concept beliefs in mathematicalproblem-solving: A path analysis. *Journal of Educational Psychology, 86*, 193-203.

Pajares, F., &Kranzler, J. (2011). Self-efficacy beliefs and general mental ability in mathematicalproblem-solving. *Contemporary Educational Psychology, 20*, 426–443.

Rich, B., Schmidt, P. (2014), *Schaum's Outline of Theory and Problems of Elementary Algebra*, The McGraw-Hill Companies, ISBN 0-07-141083-X,290-291.

Ruffell, M., Mason, J., and Allen, B. (2008). Studying attitude to mathematics. *Educational Studies in Vietnam.*

Schul, J.E. (2011). *Revisiting an old friend: The practice and promise of cooperative learning for the twenty-first century*. The Social Studies, 102, 88-93.

Sinnes, A. (2006). Three Approaches to Gender Equity in Science Education. *Nordina*3: 72-83.

Sharan, Y. (2010). Cooperative Learning for Academic and Social Gains: valued pedagogy, problematic practice. *European Journal of Education,* 45,(2), 300-313.

Sheehy, L. A. (2004). Using Student Voice to Deconstruct Cooperative, Mathematical Problem Solving. A Dissertation Submitted to the Graduate School of The University of Georgia, 2004.

Shindler, J. (2010). *Transformative classroom management*. San Francisco, CA: Jossey Bass.

Siltala, R., Suomala, J., Taatila, V. &Keskinen, S. (2014). Cooperative Learning in Finland and in California during the innovation process. Haarlem: Inholland University.

Slavin, R. E. (2011) "Achievement effects of ability grouping in secondary schools: a *STAN 51st Annual Conference Proceedings,* 56. 215-218.

Sterling, P., Mary J. (2010), *Algebra For Dummies*, Wiley Publishing, ISBN 978-0-470-559642

Swetman, D. (2005). Rural Elementary Students' attitudes toward mathematics, rural education.*International Journal of Computer Technology and Application, 6(3),* 20-22.

Tarim, K.(2009). The effects of cooperative learning on preschoolers' mathematics problem solving ability. Educ. Stud. Math.,. DOI: 10.1007/s10649-069-9197-x

Terwel, J., Herfs, P. G. P., Mertens, E. H. M., &Perrenet, J. (2010). Cooperative learning and adaptive instruction in a mathematics curriculum. *Journal of Curriculum studies, 26*(2), 17-233.

Thanh-Pham, T. (2010). Group Composition of Cooperative Learning: Does HeterogeneousGrouping Work in Asian Classrooms? *International Education Studies,* 3(3), 12-19.

Thanh-Pham, T. (2010). Implementing a Student-Centered Learning Approach at Vietnamese Higher Education Institutions: Barriers under Layers of Casual Layered Analysis (CLA).*Journal of Futures Studies,* 15(1), 21-38.

Tobias, S. & Duffy, S (2009). They're Not Dumb, They're Different: Stalking the Second Tier. Research Corporation.

Van Schaik, M., Van Oers, B., Terwel, J. (2010).Towards a knowledge-rich learning environment in preparatory vocational secondary education. *British Educational Research Journal, 32* (1) 1-21

Vermeer, J.Boekaerts, H. M.&Seegers, G. (2013) Motivational and gender differences: Sixth grade students' mathematical problem solving behavior. *Journal of Educational Psychology, 92(2),* 308-315.

Winne, P. H. & Nesbit, J. C. (2010). The psychology of academic achieve-ment. *Annual Review of Psychology, 61*, 653-678.

Zakaria, E., Chin, L. C., &Daud, Y. (2010). The effects of cooperative learning on students' mathematics achievement and attitude towards mathematics. *Journal of Social Sciences, 6* (2), 272-275.

Zakaria, E., Solfitri, T., Daud, Y., &Abidin, Z. Z. (2013). Effect of cooperative learning on Secondary school students' mathematics achieve-ment. *Creative Education, 4*, 98-100.

Zehm, S.&Kottler, J. (2013). *On being a teacher: The human dimension*. Cambridge University Press.

Zemelman, A., Daniels, J. and Hycles, R. (2013). *Basic Technical Mathematics with Calculus, Seventh Edition*. Addison Wesley Longman, Inc. ISBN 0-201-35666-X.

Apendix A

Students Attitude Assessment Scale (SAAS)

Dear Respondent,

I am a postgraduate student of Ahmadu Bello University, Zaria (ABU, Zaria) conducting a research on 'Impact of Jigsaw I Learning Strategy on Students' Attitude and Performance in Algebra, in Zaria Senior Secondary Schools, Kaduna State, Nigeria'. Below is Students Attitude Assessment Scale (SAAS). Please respond to the items according to the instructions.

Thank you.

Instructions: This instrument consists of 30 items about your attitude towards algebra. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Tick the option that most corresponds to how each statement best describes your feelings. The best answer is your honest answer as the result will be a more accurate reflection of your attitude towards algebra. Please answer every question.

Please use these response codes:

SA = Strongly Agree

A = Agree

UD = Undecided

DA = Disagree

SD = Strongly Disagree

Time allowed: 25 minutes

S/n	Statement	SA	A	UD	DA	SD
1	Quadratic equation is a very worthwhile concept in mathematics.					
2	I will want to develop my skills in algebra.					
3	I get a great deal of satisfaction from solving problems in algebra.					
4	Algebra helps develop critical thinking skills.					
5	Algebra is important in everyday life.					
6	Algebra is one of the most important topics in mathematics.					
7	Algebra would be very helpful no matter what I decide to study.					
8	I can think of many ways using algebra outside school.					
9	Algebra is one of my most interesting topics.					
10	Algebra does not scare me at all.					
11	I have a lot of self-confidence when it comes to algebra.					
12	I am able to solve algebraic problems without any difficulty.					
13	I expect to do well in any algebra test I take.					
14	I believe I am good in algebra					
15	I learn algebra easily.					
16	I am confident that I could learn advanced mathematics using algebraic concepts.					
17	I enjoyed studying algebra.					
18	I like to solve new problems in algebra.					
19	I would prefer to do an assignment in algebra than in english.					
20	I really like algebra now.					
21	I am happier in my algebra class than in any other class.					
22	Algebraic problems are very simple to solve.					
23	I am willing to take more than the required amount of algebra problems.					
24	I wish all subjects were like algebra.					
25	The challenge of algebra appeals to me.					
26	I think studying algebra is useful.					
27	I believe studying algebra will help me solve domestic problems.					
28	I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in algebra.					
29	I am comfortable answering questions in algebra class.					
30	A good skill in algebra will help me in any professional life.					

Source: Martha Tapia (1996)

ApendixB

PRE-ALGEBRA ACHIEVEMENT TEST (PAAT) pre-test

Dear Respondent,

I am a postgraduate student of Ahmadu Bello University, Zaria (ABU, Zaria) conducting a research on 'Impact of Jigsaw I Learning Strategy on Attitude and Students' Performance in Algebra in Zaria Senior Secondary Schools, Kaduna State, Nigeria'. Below is Algebra Achievement Test. Please respond to the items according to the instructions.

Thank you.

Instructions

Attempt all questions. Each respondent is required to fill his/her personal data in section A and tick the correct option as appropriate from the options in section B.

Time allowed: 60 mins

Section A :Biodata of student

1. School :……
2. Class :……
3. Age :……
4. Male/Female :…….

Section B

1 simplify $8x^2z/10xyz$

a) $\frac{4x}{5y}$

b) $\frac{4}{5x}$

c) $\frac{4x}{5}$

d) $\frac{x}{5y}$

2 Solve the equation $3x^2 + x - 2 = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x =$ or 2

c) $x = -1$ or $\frac{2}{3}$

d) $x = \frac{4}{3}$ or 2

3 Solve the equation $2x^2 - 5x + 2 = 0$

a) $x = -\frac{1}{2}$ or 2

b) $x =$ or 2

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{4}{3}$ or 2

4 Solve the equation $2x^2 - x - 1 = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x =$ or 2

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{1}{2}$ or 2

5 Solve the equation $2x^2 - 15x = 27$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x =$ or 2

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{3}{2}$ or 9

6 Solve the equation $2x^2 - 15x + 27$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x =$ or 2

c) $x = 3$ or $\frac{9}{2}$

d) $x = \frac{1}{2}$ or 2

7 Find the common difference of the arithmetic progression: 18,12,6,0, . . .

a) -6

b) 6

c) -2

d) 2

8 Solve the equation $4x^2 - 12x = -5$

a) $x = -\frac{1}{2}$ or $\frac{5}{2}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{1}{2}$ or 2

9 Solve the equation $8x^2 - 50x + 75 = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{1}{2}$ or 2

10 Solve the equation $8x^2 - 49x + 45 = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x = 3$ or $-\frac{25}{8}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{1}{2}$ or 2

11 Solve the equation $12x^2 - 11x = -2$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{2}{3}$ or $\frac{1}{4}$

12 Solve the equation $10x^2 - 43x + 45 = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x = \frac{5}{2}$ or $\frac{9}{2}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{2}{3}$ or $\frac{1}{4}$

13 Find the 8th term of the GP: $1, -2, 4, \ldots$

a) -128

b) 128

c) 182

d) -182

14 Solve the equation $3x^2 = 11x - 6$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x = 3$ or $\frac{2}{3}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{1}{2}$ or 2

15 The 18th term of an arithmetic progression is 25.find its first term if its common difference is 2.

a) -9

b) 9

c) -6

d) 6

16 Solve the equation $(4x - 1)(2x + 3) = 0$

a) $x = 2$ or $-\frac{1}{5}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = \frac{1}{4}$ or $-\frac{3}{2}$

d) $x = \frac{1}{2}$ or 2

17 Solve the equation $(2x - 7)(x + 2) = 0$

a) $x = 2$ or $-\frac{1}{5}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = \frac{5}{2}$ or $\frac{15}{4}$

d) $x = \frac{7}{2}$ or -2

18 Solve the equation $(11 - 4x)^2 = 0$

a) $x = \frac{11}{4}$ or $-\frac{1}{5}$

b) $x = \frac{1}{4}$ or $-\frac{1}{2}$

c) $x = \frac{11}{4}$ or $\frac{15}{4}$

d) $x = \frac{11}{4}$ twice

19 Solve the equation $\frac{7}{3} + \frac{2}{e} = e$

a) $e = 3, -\frac{2}{3}$

b) $e = \frac{2}{3}, -\frac{2}{3}$

c) $e = -3, -\frac{2}{3}$

d) $e = 3, -3$

20 Find the quadratic equation whose roots are 2 and 5

a) $x^2 + 7x + 10 = 0$
b) $x^2 - 7x + 10 = 0$
c) $x^2 - 7x - 10 = 0$
d) $x^2 - 5x + 10 = 0$

21 Find the quadratic equation whose roots are 5 and -5

a) $x^2 + 5x + 25 = 0$
b) $x^2 - 7x + 10 = 0$
c) $x^2 - 5x - 25 = 0$
d) $x^2 - 25 = 0$

22 Find the quadratic equation whose roots are 0 and 3

a) $x^2 - 3x = 0$
b) $x^2 - 3x + 10 = 0$
c) $x^2 + 3x = 0$
d) $x^2 - 3x - 10 = 0$

23 Find the quadratic equation whose roots are -3 and 4

a) $x^2 - x + 12 = 0$
b) $x^2 - x - 12 = 0$
c) $x^2 + x + 12 = 0$
d) $x^2 - 6x + 36 = 0$

24 Find the quadratic equation whose roots are 6 twice

a) $x^2 - 12x + 36 = 0$
b) $x^2 - 6x - 36 = 0$
c) $x^2 + 12x + 36 = 0$
d) $x^2 - 3x + 12 = 0$

25 Solve the simultaneous equation $4x - 3y = 11 \; and \; 2x + 5y = 25$

a) $x = 5, y = 3$

b) $x = 3, y = 5$

c) $x = -3, y = 5$

d) $x = 3, y = -5$

26 If 4 times a number is subtracted from the square of the number, the result is 12. Find the number.

a) -2, 6

b) 5, 15

c) -2 or 15

d) -2, 17

27 Solve the simultaneous equations $3x + 2y = 42 \; and \; 5x - 4y = 26$.

a) $x = 6, y = 10$

b) $x = 10, y = 6$
c) $x = -6, y = 10$
d) $x = -10, y = 6$

28 Solve the equations
$x + 2y = 7$ *and* $2x - 3y = -\frac{7}{2}$
a) $x = 2, y = \frac{7}{2}$
b) $x = 2, y = \frac{5}{2}$
c) $x = -2, y = \frac{7}{2}$
d) $x = -2, y = \frac{5}{2}$

29 Find the 9th term of the AP 18,12,6,0, . . .
a) -30
b) 30
c) 18
d) -18

30 Solvethe equation $8x^2 - 50x + 75 = 0$
a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$
b) $x = \frac{1}{4}$ or $-\frac{1}{2}$
c) $x = \frac{5}{2}$ or $\frac{15}{4}$
d) $x = \frac{1}{2}$ or 2

31 Solve the simultaneous equations
$2x + 5y = 1, 3x - 2y = 30$
a) 8,-3
b) 4, 6
c) $\frac{2}{5}, \frac{1}{2}$
d) -2, 1

32 Solve the equations
$\frac{1}{2}x + \frac{1}{3}y = 4, \frac{1}{4}y - \frac{1}{3}x = \frac{1}{6}$
a) 8,-3
b) -2, 1
c) $\frac{2}{5}, \frac{1}{2}$
d) 4, 6

33 Solve the equations
$\frac{2}{x} - \frac{1}{y} = 3, \frac{4}{x} - \frac{3}{y} = 16$
a) 8,-3
b) -2, 1
c) $\frac{2}{5}, \frac{1}{2}$
d) 4, 6

34 Solve the equation
$c = \frac{3}{c+2}$
a) 1,-3
b) $\frac{2}{5}, \frac{1}{2}$
c) -2, 1
d) 4, 6

35 Find *x and y if* $3^{2x-y} = 1$ *and* $\frac{16}{4}^{x} = 8^{3x-y}$
a) 8,-3
b) *2,4*
c) $\frac{2}{5}, \frac{1}{2}$
d) -2, 1

36 7 cups and 8 plates cost N6.30. 8 cups and 7 plates cost N6.45. Calculate the cost of a cup and a plate
a) Cup= 50K, plate= 35K
b) Cup= 45K, plate= 35K
c) Cup= 50K, plate= 30K
d) Cup= 50K, plate= 50K

37 Solve the equations
$2x - y = 8, 3x + y = 17$
a) 5, 2
b) -2, 1
c) $\frac{2}{5}, \frac{1}{2}$
d) 4, 6

38 Solve the equations
$3x - y = 3, 9x^2 - y^2 = 45$
a) $x = -\frac{2}{5}$ and $y = -\frac{3}{2}$
b) $x = 3$ and $y = 6$
c) $x = 0$ and $y = \frac{2}{5}$
d) $x = -\frac{4}{3}$ and $y = 2$

39 Find the common ratio of the geometric progression: $\frac{1}{4}, -\frac{1}{2}, 1, ...$

a) -2

b) 2

c) $\frac{1}{4}$

d) $\frac{1}{2}$

40 Solve the equation $\frac{x-2}{x+4} = x$

a) $x = -1, -2$

b) $x = 1,2$

c) $x = -1,2$

d) $x = 1, -2$

41 The lengths of an equilateral triangle in given in terms of x, y and z as $4x$cm, 3ycm and $(x + y + z)$cm. find x and y

a) $x = -\frac{2}{5}$ and$y = \frac{3}{2}$

b) $x = 3$ and $y = 6$

c) $x = 1\frac{4}{5}$ and$y = 2\frac{2}{5}$

d) $x = -3\frac{1}{2}$ and $y = 5$

42 In a positive number of two digits, the sum of the digits is 15. If the digits are interchanged, the number is increased by 9. Find the number.

a) *78*

b) *87*

c) *-78*

d) -87

43 Solve the equations $3x + y = 25, xy = 8$

a) (1,1) or $(1\frac{2}{3}, -2\frac{1}{3})$

b) (-1,1) or $(1\frac{2}{3}, 2\frac{1}{3})$

c) (1,1) or $(1\frac{2}{3}, 2\frac{1}{3})$

d) (1,1) or $(-1\frac{2}{3}, 2\frac{1}{3})$

44 The product of two numbers is 12. The sum of the larger number and twice the smaller number is 11. Find the two numbers.

a) *3 and 4*

b) *6 and 2*

c) 8 and $1\frac{1}{2}$

d) 12 and 1

45 Solve the equations $x^2 - 4y^2 = 9, x = 2y = 1$

a) $x = -\frac{2}{5}$ and $y = \frac{3}{2}$

b) $x = 3$ and $y = 1$

c) $x = 5$ and $y = -2$

d) $x = -\frac{4}{3}$and $y = 2$

46 Solve the equations $x + 2y = 13, 2x - 3y = 5$

a) $x = -\frac{2}{5}$ and $y = \frac{3}{2}$

b) $x = 7$ and $y = 3$

c) $x = 5$ and $y = -2$

d) $x = -\frac{4}{3}$and $y = 2$

47 Solve the equations
$2x - y = 5, 3x + 2y = -24$

a) $x = -2$ and $y = -9$

b) $x = 7$ and $y = 3$

c) $x = 5$ and $y = -2$

d) $x = -\frac{4}{3}$ and $y = 2$

48 Solve the equations
$x + \frac{y}{x} = \frac{1}{2}$, $\frac{x}{2} - \frac{y}{6} = 1\frac{1}{2}$

a) $x = -2$ and $y = -9$

b) $x = 7$ and $y = 3$

c) $x = 2$ and $y = -3$

d) $x = -\frac{4}{3}$ and $y = 2$

49 If 1 is added to both numerator and denominator of a fraction, the fraction becomes $\frac{1}{2}$. If is added to both, the fraction becomes $\frac{2}{3}$. what is the fraction?

a) $\frac{3}{13}$

b) $\frac{6}{13}$

c) $\frac{6}{7}$

d) $\frac{6}{12}$

50 Solve the equation $\frac{3}{a} = a - 2$,

a) $a = 3, -1$

b) $a = -3, -1$

c) $a = 3,1$

d) $a = -3,1$

PRE-ALGEBRA ACHIEVEMENT TEST MARKING SCHEME

1	A	20	B	39	A
2	C	21	D	40	A
3	A	22	A	41	C
4	D	23	B	42	A
5	D	24	A	43	C
6	C	25	A	44	C
7	A	26	A	45	C
8	A	27	B	46	B
9	C	28	B	47	A
10	B	29	A	48	C
11	D	30	C	49	B
12	B	31	A	50	A
13	A	32	D		
14	B	33	C		
15	A	34	A		
16	C	35	B		
17	D	36	A		
18	D	37	A		
19	A	38	B		

Appendix C

ALGEBRA ACHIEVEMENT TEST (AAT) post-test

Dear Respondent,

I am a postgraduate student of Ahmadu Bello University, Zaria (ABU, Zaria) conducting a research on 'Impact of Jigsaw I Learning Strategy on Attitude and Students' Performance in Algebra in Zaria Senior Secondary Schools, Kaduna State, Nigeria'. Below is Pre-Algebra Achievement Test. Please respond to the items according to the instructions.

Thank you.

Instructions

Attempt all questions. Each respondent is required to fill his/her personal data in section A and tick the correct option as appropriate from the options in section B.

Time allowed: 60 mins

Section A :Biodata of student

5. School :…….
6. Class :…….
7. Age :……
8. Male/Female :…….

Section B

1 Solve the equation (x - 2)(x + 7) = 0

a) x = 0 or -3

b) x = 2 or -7

c) x = 5 twice

d) x = $\frac{1}{2}$ or 3½

2 Find the sum of all multiples of 3 between 0 and 200.

a) 2277

b) 2287

c) 2288

d) 7722

3 Solve the equation $(x - 5)^2 = 0$

a) x = 0 or -3

b) x = 2 or -7

c) x = 5 twice

d) x = $\frac{1}{2}$ or 3½

4 Solve the equation(3x + 2)(2x -7)= 0

a) x = 0 or -3

b) x = - $\frac{2}{3}$ or $3\frac{1}{2}$

c) x = 5 twice

d) x = $\frac{1}{2}$ or 3½

5 Solve the equation $4x^2 + 5x – 21 = 0$

a) -3 or $1\frac{3}{4}$

b) -4 or $2\frac{1}{2}$

c) -1 or x =$2\frac{1}{2}$

d) 0 or 3

6 Solve the equation $x^2 – 3x = 0$

a) -3 or $1\frac{3}{4}$

b) -4 or $2\frac{1}{2}$

c) -1 or x =$2\frac{1}{2}$

d) 0 or 3

7 Solve the equation $5x^2 – 6x – 3 = 0$. Give the roots correct to 2 decimal places.

a) -1.62 or 2.10

b) 1.85 or 0.38

c) 1.58 or 0.83

d) 1.58 or 1.38

8 Find the quadratic equation whose roots are 4 and $-1\frac{2}{3}$

a) $3x^2 – 7x - 20 = 0$

b) $3x^2 + 7x - 20 = 0$

c) $3x^2 – 7x + 20 = 0$

d) $3x^2 +7x + 20 = 0$

9 An arithmetic progression has 15 terms and a common difference of 3. Find the first and last term if its sum is 120.

a) 29 or -13

b) 29 or 13

c) -29 or -13

d) 0 or 3

10 The 18^{th} term of an arithmetic progression is 25.find its first term if its common difference is 2.

a) -9

b) 9

c) -6

d) 6

11 Find two numbers whose difference is 5, and whose product is 266.

a) 12 and 14

b) 14 and 17

c) 14 and 19

d) 19 and 21

12 The length of a rectangular compound is 5 metres more the width, and the area is $266m^2$. Find the dimensions of the compound.

a) 12m and 14m

b) 14m and 17m

c) 14m and 19m

d) 19m and 21m

13 A two digit number is such that its tens digit is greater than its units digit by 4. The two-digit number is less than 4 times the product of its digits by 11. Find the number.

a) 73

b) 37
c) 57
d) 75

14 Solve the equation $3x^2 + 3x - 18 = 0$, using the quadratic formula

a) x = -3,2
b) x = -3,-3
c) $x = -3 \pm \sqrt{\frac{12}{2}}$
d) $x = -3 \pm \sqrt{\frac{2}{21}}$

15 Simplify $(a^2 - 4)/(a^2 - 3a+2) \div (a)/(a-1)$

a) $\frac{a+2}{a}$

b) $\frac{a-2}{a}$

c) $\frac{a+2}{a-2}$

d) $-\frac{a+2}{a}$

16 Find the common ratio of the geometric progression: $\frac{1}{4}, -\frac{1}{2}, 1, \ldots$

a) -2

b) 2

c) $\frac{1}{4}$

d) $\frac{1}{2}$

17 Solve $x^2 - 7x = 0$.

a) $x = -1$ or 4

b) $x = -2$ or 2

c) $x = 0$ or 7

d) $x = -\frac{4}{3}$ or 2

18 Simplify $\frac{a-4}{7} = \frac{2}{3a-1}$

a) $5, -\frac{2}{3}$

b) $-5, -\frac{2}{3}$

c) $5, \frac{2}{3}$

d) $-5, \frac{2}{3}$

19 Solve $4x^2 + 5x - 21 = 0$

a) $x = -\frac{2}{5}$ or $-\frac{3}{2}$

b) $x = -3$ or $1\frac{3}{4}$

c) $x = 0$ or $\frac{2}{5}$

d) $x = -\frac{4}{3}$ or 2

20 Solve $5x^2 = 2x$

a) $x = -\frac{2}{5}$ or $-\frac{3}{2}$

b) $x =$ or 2

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{4}{3}$ or 2

21 Find two numbers which differ by 4, and whose product is 45.

a) 14, 19

b) 7, -6

c) 9, 5

d) 8, 15

22 The length of a room is 3 metres longer than its breadth. The area of the room is 28 m^2. Find its dimension.

a) 7m by 3m

(b) 1m by 9m

(c) 7m by 4m

(d) 9m by 3m

23 If a number is increased by 30, it is less than its square by 12. Find the number.

a) 14, 19

b) 7, -6

c) 9, 5

d) 8, 15

24 Two numbers differ by 7.if their product is 120, find the numbers.

a) 14, 19

b) 7, -6

c) 9, 5

d) 8, 15

25 The numerator of a fraction is 5 less than its denominator. If 6 is added to the numerator and 4 to the denominator, the fraction is doubled. What is the fraction?

a) $\frac{3}{8}$

b) $\frac{4}{9}$

c) $\frac{5}{10}$

d) $\frac{10}{15}$

26 If 4 times a number is subtracted from the square of the number, the result is 12. Find the number.

a) -2, 6

b) 5, 15

c) -2 or 15

d) -2, 17

27 Two numbers differ by 2. The sum of their square is 244. Find the numbers.

a) 0, 2

b) 5, 7

c) 1, 3

d) 10, 12

28 Find two numbers whose difference is 5 and whose product is 266.

a) 7, -6

b) 14, 19

c) 9, 5

d) 8, 15

29 Solve the equation

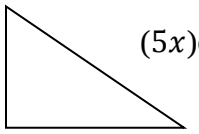
$(3x + 2)(2x - 7) = 0$

a) $x = -\frac{2}{3}$ or $3\frac{1}{2}$

b) $x =$ or 2

c) $x = 0$ or $\frac{2}{5}$

d) $x = \frac{4}{3}$ or 2

$(6 + x)$cm  $(5x)$cm

30 figure 1

$(4 + x)$ cm

The right angled triangle has its dimensions as shown in figure 1. Given than x is a whole number, find x

a) 2
b) 5
c) 7
d) 9

31 A GP has 8 terms. Its first and last term are 0.3 and 38.4. Calculate its common ratio.

a) 2
b) 4
c) $\frac{1}{2}$
d) $\frac{1}{4}$

32 Find the 8th term of the GP: 1, -2,4, . . .

a) -128

b) 128

c) 182

d) -182

33 Find the 9th term of the AP 18,12,6,0, . . .

a) -30

b) 30
c) 18
d) -18

34 Solve the simultaneous equation

$3x + 5y = 47 \; and \; 2x + 3y = 29$

a) $x = -7, y = -4$

b) $x = 7, y = 4$

c) $x = -4, y = 7$
d) $x = 4, y = 7$

35 Solve the simultaneous equations

$2x - y = 10, and \; 3x + y^2 = 22$

a) $x = 6 \; or \frac{13}{4}, y = 2 \; or \; \frac{7}{2}$

b) $x = 6 \; or \; -\frac{13}{4}, y = 2 \; or -\frac{7}{2}$

c) $x = 6 \; or \frac{13}{4}, y = 2 \; or -\frac{7}{2}$

d) $x = -6 \; or \frac{13}{4}, y = -2 \; or \; \frac{7}{2}$

36 Calculate the sum of the terms of the GP in question 31

a) 76.5

b) 76
c) 75.6
d) 765

37 Solve the equations

$x + 2y = 7 \; and \; 2x - 3y = -\frac{7}{2}$

b) $x = 2, y = \frac{7}{2}$

b) $x = 2, y = \frac{5}{2}$

c) $x = -2, y = \frac{7}{2}$

d) $x = -2, y = \frac{5}{2}$

38 Solve the equations

$3m - 5n = 11 \; and \; 4m - 6n = 11$

a) $m = 11, n = -\frac{11}{2}$

b) $m = 7, n = -2$
c) $m = -7, n = 2$
d) $m = -7, n = -2$

39 Solve the simultaneous equation

$12m + 12n = -7 \; and \; 4m - 3n = 7$

a) $m = -\frac{3}{4}, n = -\frac{4}{3}$

b) $m = \frac{3}{4}, n = -\frac{4}{3}$

c) $m = -\frac{3}{4}, n = \frac{4}{3}$

d) $m = \frac{3}{4}, n = \frac{4}{3}$

40 Solve the simultaneous equation $xy + x = 28\ and\ x = y + 4$

a) $x = 1 or -4, y = 3 or -8$

b) $x = 3 or -8, y = 1 or -4$

c) $x = 7 or -4, y = 3 or -8$

d) $x = 1 or -4, y = -3 or -8$

41 Simplify $(a^2–2a-3)/(a^2–16)\times(a+4)/(a^2+8a+15)$

a) $\frac{a-1}{(a-4)(a+5}$

b) $-\frac{a-1}{(a-4)(a+5}$

c) $\frac{a}{(a-4)(a+5}$

d) $\frac{a-1}{(a-4)(a-5}$

42 Solve the equations $2x + 4y = 42\ and\ 6x - 4y = 30$

a) $x = 9, y = -6$

b) $x = 6, y = 9$

c) $x = -6, y = 9$

d) $x = 9, y = 6$

43 Solve the equations $7x + 5y = 11\ and\ 7x - 4y = 29$

a) $x = 3, y = 2$

b) $x = 3, y = -2$

c) $x = -3, y = 2$

d) $x = -3, y = -2$

44 Simplify $(a^2- b^2)/(b^2-ab)$

a) $-\frac{a+b}{b}$

b) $\frac{a+b}{b}$

c) $-\frac{a-b}{b}$

d) $-\frac{a}{a+b}$

45 Simplify $(a^2-5a+6)/(2-3a+a^2)$

a) $\frac{a-3}{a-1}$ or $-\frac{a-3}{1-a}$

b) $\frac{a-3}{a+1}$ or $-\frac{a-3}{1-a}$

c) $\frac{a-3}{a-1}$ or $\frac{a-3}{1-a}$

d) $-\frac{a-3}{a-1}$ or $-\frac{a-3}{1-a}$

46 The perimeter of a rectangular lawn is 32m, while the area is $60m^2$. Find the breadth of thelawn.

a) 6 or 10

b) 3 or 20

c) 4 or 15

d) 5 or 6

47 The area of a rectangle is 68cm, the perimeter is 42cm. find the length of its side.

a) 16cm and 3cm

b) 17cm and 4cm

c) 18cm and 5cm

d) 20cm and 5cm

48 A number is made up of two digits. The sum of the digits is 11. If the digits areinterchanged, the original number is increased by 9. Find the number.

a) 29

b) 38

c) 47

d) 56

49 Sunny is twice as old as Wale. Four years ago, he was four times as old as Wale. Whatare their present ages?

a) 12 yrs and 6 yrs

b) 10 yrs and 5 yrs

c) 8 yrs and 4 yrs

d) 6 yrs and 3 yrs.

50 The product of two consecutive positive odd numbers is 195. What are the numbers?

a) -15 and 13

b) -15 and -13

c) 15 and -13

d) 15 and 13

ALGEBRA ACHIEVEMENT TEST MARKING SCHEME

1	B	20	C	39	B
2	A	21	C	40	C
3	C	22	C	41	A
4	B	23	B	42	D
5	A	24	D	43	B
6	D	25	D	44	D
7	A	26	A	45	A
8	A	27	D	46	A
9	A	28	B	47	B
10	A	29	A	48	D
11	C	30	A	49	A
12	C	31	A	50	D
13	A	32	A		
14	A	33	A		
15	A	34	D		
16	A	35	C		
17	C	36	A		
18	A	37	B		
19	B	38	A		

Appendix D

Jigsaw I Learning Strategy Lesson Plans - Experimental Group

Lesson 1 Simultaneous Equation

Subject: mathematics

Topic: Simultaneous Equation (substitution method)

Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 solve simultaneous linear equation using substitution method

2 Solve simultaneous linear equation by elimination method

3 solve linear and quadratic simultaneous equation

Previous Knowledge: students are familiar with substitution in linear algebraic expressions, such as; 'if $y = 2\ and\ x = 3, evaluate\ 6x - xy$'

Instruction materials: expert sheet, work book, students' manual and graph paper.

Introduction: The teacher introduces the lesson by briefing the students on Jigsaw I Learning Strategy and solving elementary algebraic problem involving substitution.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn simultaneous equation using Jigsaw I Learning Strategy, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students was then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Lesson 2 Quadratic Equation

Subject: mathematics

Topic: Quadratic Equation

Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 express quadratic equations in the form $ax^2 + bx + c = 0$

2 solve quadratic equation by factorization method

3 solve quadratic equation by completing square method.

4 solve quadratic equation using quadratic formula

Previous Knowledge: students are familiar with elementary algebraic expressions such as quadratics expression.

Instruction materials: expert sheet, work book, students' manual, chalk and chalkboard.

Introduction: The teacher introduces the lesson by briefing the students on quadratic equations and that Jigsaw I Learning Strategy was used for the present lesson.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn quadratic equation using Jigsaw I Learning Strategy model, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students was then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Lesson 3 Algebraic Fractions

Subject: mathematics

Topic: Simplification of Algebraic Fractions
Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 Factorise algebraic fractions

2 Add algebraic fractions and

3 Subtract algebraic fractions correctly

Previous Knowledge: students are familiar with elementary algebraic expressions such as quadratics expression.

Instruction materials: expert sheet, work book, students' manual, chalk and chalkboard.

Introduction: The teacher introduces the lesson by briefing the students on algebraic fractions and that Jigsaw I Learning Strategy will be used for the present lesson.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn simplification of algebraic fractions using Jigsaw I Learning Strategy model, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students will be then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Lesson 4 Algebraic Fractions

Subject: mathematics

Topic: Algebraic Fractions

Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 determine when a fraction is undefined

2 multiply algebraic fractions

3 divide algebraic fractions correctly

Previous Knowledge: students are familiar with simplification of common fractions.

Instruction materials: expert sheet, work book, students' manual, chalk and chalkboard.

Introduction: The teacher introduces the lesson by briefing the students on algebraic fractions and that Jigsaw I Learning Strategy will be used for the present lesson.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn how to determine when a fraction is undefined, and operations with algebraic fractions, using Jigsaw I Learning Strategy model, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students will be then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Lesson 5 Arithmetic Progression

Subject: mathematics

Topic: Arithmetic Progression

Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 memorise and apply the formula for finding the nth term of an AP

2 memorise and apply the formula for calculating sum of an AP

3 find the nth term of an Arithmetic Series

4 find the Sum of an Arithmetic Series

Previous Knowledge: students are familiar with memorization and substitution into algebraic formulae

Instruction materials: expert sheet, work book, students' manual, chalk and chalkboard.

Introduction: The teacher introduces the lesson by briefing the students on Arithmetic Progression and that Jigsaw I Learning Strategy will be used for the present lesson.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn how to calculate the nth term and the sum of an Arithmetic Progression, using Jigsaw I Learning Strategy model, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students will be then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Lesson 6 Geometric Progression

Subject: mathematics

Topic: Geometric progression

Class: SSII

Average age: 17 years

Duration: 80 minutes

Instructional Method: Jigsaw I Learning Strategy

Behavioral Objectives: by the end of the lesson, students should be able to;

1 recall and apply the formula for finding the sum of a GP

2 find the sum of a geometric progression

Previous Knowledge: students are familiar with memorization and substitution into algebraic formulae

Instruction materials: expert sheet, work book, students' manual, chalk and chalkboard.

Introduction: The teacher introduces the lesson by briefing the students on Geometric Progression and that Jigsaw I Learning Strategywill be used for the present lesson.

Presentation: The teacher presents the lesson in the following Jigsaw I Learning Strategy steps

Step 1: The teacher presents the lesson by explaining to students that they are going to learn how to calculate the sum of a GP, using Jigsaw I Learning Strategy model, where all students will work cooperatively.

Step 2: Study materials and activity sheets are distributed among the groups.

Step 3: Students will be then grouped into their jigsaw group (home group) of 4 to 6 students per group.

Step 4: Individual studies; each student will study his/her study manual for about 20 minutes.

Step 5: Expert group interaction; students in their expert group discuss and agree on their response to the activities.

Step 6: Home group presentation; student returned from expert group to their jigsaw groups for about 10 minutes discussion.

Step 7: Evaluation; this is done by sitting-in on a group session and evaluate students' ability to effectively teach their group all they learnt in their expert group.

Appendix E

Jigsaw I Learning Strategy Activity Sheets

Activity sheet 1 **Time: 30 minutes**

Solutions of quadratic equations
(Factorization method)

Definition: quadratic equation is an equation of the form $ax^2 + bx + c = 0$, where $a \neq 0$ and a, b and c are constants. It can also be defined as an equation whose highest power of the unknown is 2. In this case, x represents the unknown variable.

To solve a quadratic equation means to find its roots.

To find the roots;

Arrange the equation in the form $ax^2 + bx + c = 0$

Factorize the LHS if possible.

Use the result that if pq = 0, then p = 0 or q = 0, where p and q are any quantity.

If quadratic equation $ax^2 + bx + c = 0$ cannot be factorized, solve either:

By completing the square method, graphical method or

By applying the quadratic formula; $x = \dfrac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$

Example1.

Solve the equation $x^2 - 7x + 12 = 0$

Compute the product of the square term (x^2) and the constant term; $x^2 \times 12 = 12x^2$

Find two possible factors of $12x^2$ such that their sum gives the middle term; $-7x$

Factors of $12x^2$ are;

x and $12x$ $\quad -x$ and $-12x$

$2x$ and $6x$ $\quad -2x$ and $-6x$

$3x$ and $4x$ $\quad -3x$ and $-4x$

The required factors are $-3x$ and $-4x$

Replace the middle term with the required factors

$x^2 - 7x + 12 = 0$ becomes $x^2 - 3x - 4x + 12 = 0$

Group in two$_s$ and factorizes

$\rightarrow x(x-3) - 4(x-3) = 0$

$\rightarrow (x-4)(x-3) = 0$

Either $(x-4) = 0 \; or (x-3) = 0$

$x = 4 \; or \; x = 3$

The roots of the equation are;

$x = 4,3$

Example 2

Solve the equation $x^2 - 7x + 10 = 0$

The required factors are; $-5x$ and $-2x$

The given equation becomes $x^2 - 5x - 2x + 10 = 0$

Factorizing gives $(x-5)(x-2) = 0$

Then either $(x-5) = 0 \; or \; (x-2) = 0$

$x = 5 \; or \; x = 2$

Example 3

Solve the quadratic equation $6x^2 - 7x + 2 = 0$

The required factors are; $-3x \; and \; -4x$

The given equation becomes $6x^2 - 4x - 3x + 2 = 0$

Group into two$_s$ and factorize

$$(2x - 1)(3x - 2) = 0$$

Either

$$(2x - 1) = 0 \; or \; (3x - 2) = 0$$

$$2x = 1 \; or \; 3x = 2$$

$$x = \frac{1}{2} \; or \; x = \frac{2}{3}$$

The roots of the quadratic equation are;

$$x = \frac{1}{2}, \frac{2}{3}$$

Activities

Solve the following equations

1 $x^2 - 4x - 5 = 0$

2 $x^2 - 6x + 5 = 0$

3 $x^2 + 6x - 40 = 0$

Activity sheet 2 **Time: 30 minutes**

Solutions of quadratic equations

(Completing the square method)

Definition: quadratic equation is an equation of the form $ax^2 + bx + c = 0$, where a ≠ 0 and a, b and c are constants. It can also be defined as an equation whose highest power of the unknown is 2. In this case, x represents the unknown variable.

To solve a quadratic equation means to find its roots.

To find the roots;

Arrange the equation in the form $ax^2 + bx + c = 0$

Factorize the LHS if possible.

Use the result that if pq = 0, then p = 0 or q = 0, where p and q are any quantity. If quadratic equation $ax^2 + bx + c = 0$ is not factoriseable, solve either:

By completing the square method, graphical method or

By applying the quadratic formula; $x = \dfrac{-b \pm \sqrt{(b^2 - 4ac)}}{2a}$

Example1.

Solve the equation $3x^2 - 4x - 5 = 0$

Arrange with terms containing x^2 *and* x on L.H.S.:

$$3x^2 - 4x = 5$$

Divide through by $3x$ (the coefficient of x^2)

$$x^2 - \frac{4}{3}x = \frac{5}{3}$$

Add to each side (half the coefficient of x)^2

$$x^2 - \frac{4}{3}x + \left(-\frac{2}{3}\right)^2 = \frac{5}{3} + \left(-\frac{2}{3}\right)^2$$

$$x^2 - \frac{4}{3}x + \left(-\frac{2}{3}\right)^2 = \frac{5}{3} + \left(\frac{4}{9}\right)$$

$$\left(x - \frac{2}{3}\right)^2 = \frac{19}{9}$$

Take the square root of each side:

$$x - \frac{2}{3} = \sqrt{\frac{19}{9}} = \pm\frac{4.359}{3}$$

$$x = \pm\frac{4.359}{3} + \frac{2}{3}$$

$$x = \frac{6.359}{3} \; or \; \frac{-2.359}{3}$$

$$x = 2.12 \; or \; -0.79$$

Example 2

Solve the equation $2x^2 - x - 8 = 0$

Arrange with terms containing x^2 *and* x on L.H.S. and make the coefficient of x^2 1:

$$x^2 - \frac{1}{2}x = 4$$

Make the L.H.S. a perfect square by adding $\left(-\frac{1}{4}\right)^2$ to each side.

$$x^2 - \frac{1}{2}x + \left(-\frac{1}{4}\right)^2 = 4 + \left(-\frac{1}{4}\right)^2$$

$$\left(x - \frac{1}{4}\right)^2 = 4\frac{1}{16}$$

$$x - \frac{1}{4} = \pm\sqrt{\frac{65}{16}}$$

$$x - \frac{1}{4} = \pm\frac{8.062}{4}$$

$$x = \frac{1}{4} + \frac{8.062}{4} \; or \; x - \frac{8.062}{4}$$

$$x = 2.27 \; or \; -1.77$$

Example 3

Solve the equation $x^2 - 8x + 3 = 0$

Arrange with terms containing $x^2 \; and \; x$ on L.H.S.

$$x^2 - 8x = -3$$

Add $(-4)^2$ to both sides to make L.H.S. a perfect square

$$x^2 - 8x + (-4)^2 = -3 + (-4)^2$$

$$(x - 4)^2 = 13$$

$$x - 4 = \sqrt{13}$$

$$x = 4 - \pm\sqrt{13}$$

Activities

Solve the following equations

1 $x^2 + 4x - 21 = 0$

2 $x^2 - 14x - 45 = 0$

3 $x^2 - 2x + \frac{16}{25} = 0$

4 $2x^2 + 9x = 5$

Activity sheet 3 **Time: 30minutes**

Solutions of quadratic equations (Formula method)

Definition: quadratic equation is an equation of the form $ax^2 + bx + c = 0$, where a $\neq$ 0 and a, b and c are constants. It can also be defined as an equation whose highest power of the unknown is 2. In this case, x represents the unknown variable.

To solve a quadratic equation means to find its roots.

To find the roots;

Arrange the equation in the form $ax^2 + bx + c = 0$

Factorize the LHS if possible.

Use the result that if pq = 0, then p = 0 or q = 0, where p and q are any quantity. If quadratic equation $ax^2 + bx + c = 0$ is not factoriseable, solve either:

By completing the square method, graphical method or

By applying the quadratic formula; $x = \frac{-b \pm \sqrt{(b^2-4ac)}}{2a}$

Solutions of the equation $ax^2 + bx + c = 0$ are

$$x = \frac{-b \pm \sqrt{(b^2-4ac)}}{2a}$$

The expression $ax^2 + bx + c = 0$ can be made identical to any given quadratic equation, by giving a, b and c suitable values.

Example1.

Solve the equation $3x^2-4x - 5 = 0$

For this equation $a = 3, b = -4, c = -5$

Substitute in $x = \frac{-b \pm \sqrt{(b^2-4ac)}}{2a}$

$$x = \frac{4 \pm \sqrt{((-4)^2-4(3)(-5))}}{6}$$

$$x = \frac{4 \pm \sqrt{76}}{6}$$

$$x = \frac{4 \pm 8.718}{6}$$

$$x = \frac{12.718}{6} \; or \frac{-4.718}{6}$$

$$x = 2.12 \; or -0.79$$

Activities

Solve the following equations

1 $x^2 + 5x + 6 = 0$

2 $7x^2 + 10x + 3 = 0$

3 $4x^2 + 5x - 21 = 0$

Activity sheet 5 (Simultaneous equation)

Simultaneous equation refers to conditions where two or more unknown variables are related to each other through an equal number of equations. Consider the following equations;

$x + y = 24$

$2x - y = -6$

For these set of equations, there is but a single combination of values of x and y that will satisfy both equations. To solve this pair of simultaneous equations, therefore, three principal methods can be used:

Method 1: substitution method

Method 2: elimination method.

Method 3: graphical method

Substitution method – under the substitution method, one of the two unknowns is made the subject of the formula in one of the equations.

$x + y = 24$…….. (i)

$2x - y = -6$ ……. (ii)

$y = 24 - x$from (i)

Defining y in terms of x

Then, we take this new definition of one variable and substitute it for the same variable in the second equation.

$2x - y = -6$ becomes$2x - (24 - x) = -6$

$\rightarrow 2x - 24 + x = -6$ removing brackets

$\rightarrow 2x + x = -6 + 24$ collecting like terms

$\rightarrow 3x = 18$

Divide through by 3

$\rightarrow \frac{3}{3}x = \frac{18}{3}$

$\rightarrow x = 6$

To find y, substitute $x = 6$ in equation (ii)

$2x - y = -6$ becomes$2(6) - y = -6$

$\rightarrow 12 - y = -6$

$\rightarrow -y = -6 - 12$

$\rightarrow -y = -18$

$\rightarrow y = 18$

Example 2

Solve $3x + 2y = 24$ and $5x - 4y = 26$

$3x + 2y = 24$ ---------- (i)

$5x - 4y = 26$ ---------- (ii)

From (i), $x = \frac{42-2y}{3}$

Substitute $\frac{42-2y}{3}$ for x in (ii)

$5\left(\frac{42 - 2y}{3}\right) - 4y = 26$

$210 - 10y - 12y = 78$

$-22y = 78 - 210$

$-22y = -132$

Divide both sides by -22

$\frac{-22y}{-22} = \frac{-132}{-22}$

$y = 6$

To find x, substitute 6 for $y\ in\ (ii)$

$5x - 4y = 26$

$5x - 4(6) = 26$

$5x - 24 = 26$

$5x = 26 + 24$

$5x = 50$

$x = 10$

Therefore

$x = 10, y = 6$

Activities

1 solve the equations $7x + 5y = 11$ and $7x - 4y = 29$

2 solve the equations $\frac{1}{2}x + \frac{1}{3}y = 4$ and $\frac{1}{4}y - \frac{1}{3}x = \frac{1}{6}$

3 solve the equations $2x - y = \frac{9}{2}$and $x + 4y = 0$

4 the perimeter of a rectangular lawn is 32m, while the area is 60m^2. Find the breadth of the lawn.

5 the area of a rectangle is 68cm, the perimeter is 42cm. find the length of its side.

Activity sheet 6

Factorization of Fractions

When simplifying algebraic factions, always fully factorise the numerators and denominators. It may be possible to divide through by any factor which they have in common.

For example, simplify $(a^2+ax-6x^2)/(2x^2+ax-a^2)$

$(a^2+ax-6x^2)/(2x^2+ax-a^2)$

$$= \frac{(a-2x)(a+3x)}{(2x-a)(x+a)}$$

$$= -\frac{(a+3x)}{(x+a)}$$

Example 2

Simplify $(a^2-5a+6) / (2-3a+a^2)$

$(a^2-5a+6) / (2-3a+a^2)$

$$= \frac{(a-2)(a-3)}{(2-a)(1-a)}$$

$$= -\frac{(a-3)}{(1-a)} \text{ or } \frac{(a-3)}{(a-1)} \text{ or } \frac{(3-a)}{(1-a)} \text{ or } -\frac{(a-3)}{(a-1)}$$

Activities

Simplify the following fractions

4 $(c^2-2cd+d^2)/(c^2-cd)$

5 $(u^2+uv)/(uv+v^2)$

6 $\frac{ab+ac}{ad+ae}$

7 $(d^2-9) / (d^2-7d+12)$

8 $(15+2x-x^2) / (x^2-25)$

Activity sheet 7

Addition and Subtraction of Algebraic Fractions

When simplifying algebraic factions, always fully factorise the numerators and denominators. It may be possible to divide through by any factor which they have in common. Algebra can be added or subtracted as follows:

For example, simplify $\frac{6}{a} - \frac{3}{2b}$

$\frac{6}{a} - \frac{3}{2b}$

The LCM of a and 2b is 2ab

Express each fraction with a denominator of 2ab.

$\frac{6}{a} - \frac{3}{2b} = \frac{6\times 2b}{a\times 2b} - \frac{3\times a}{2b\times a}$

$= \frac{12b}{2ab} - \frac{3a}{2ab}$

$= \frac{12b-3a}{2ab}$

Example 2

Simplify $\frac{1}{a-2m} - \frac{2}{a+3m}$

$\frac{1}{a-2m} - \frac{2}{a+3m}$

The LCM of $a - 2m$ and $a + 3m$ is $(a - 2m)(a + 3m)$

$\frac{1}{a-2m} - \frac{2}{a+3m}$

$= \frac{a+3m-2(a-2m)}{(a-2m)(a+3m)}$

$= \frac{a+3m-2a+4m}{(a-2m)(a+3m)}$

$= \frac{7m-a}{(a-2m)(a+3m)}$

Activities

Simplify the following fractions

1 $\frac{4}{x-3} - \frac{1}{x+2}$

2 $\frac{3}{2(x+y)} - \frac{1}{3(x+y)}$

3 $\frac{7u}{2u+3v} - 3$

4 $\frac{d+1}{2d-8} - \frac{d+2}{12-3d}$

5 $\frac{e-2}{e+2} - \frac{e-1}{e+3}$

Activity sheet 8

Undefined Fractions

If the denominator of a fraction has the value zero, the fraction will be undefined. If an expression contains an undefined fraction, the whole expression is undefined.

As the value of x approaches 1, the value of $\frac{1}{x-1}$ decreases rapidly.

Example, when x = 0.999

$$\frac{1}{x-1} = \frac{1}{0.999-1} = \frac{1}{-1000} = -1000$$

When x = 1, it is impossible to say what the value of $\frac{1}{x-1}$ is.

At that point, we say $\frac{1}{x-1}$is undefined when x = 0

Example 2

Find the value of x for which $\frac{3}{x+2}$ is not defined.

$\frac{3}{x+2}$is undefined when $x + 2 = 0$

If $x + 2 = 0$

Then, $x = -2$

The function $\frac{1}{x-1}$ is not defined when $x = -2$

Example 3

Find the value of x for which $(x^2 – 2x + 3) / (x + 3)(x - 8)$ is not defined.

$(x^2 – 2x + 3) / (x + 3)(x - 8)$ is undefined when

$(x + 3)(x - 8) = 0$

If $(x + 3)(x - 8) = 0$

Then, either $x + 3 = 0$ or $x – 8 = 0$

i.e. either x = -3 or x = 8

The fraction is undefined when x = -3 or when x = 8

Activities

Find the values of x for which the following expressions are undefined.

1 $\frac{4x-3}{x(x+4)(x-9)}$

2 $\frac{2a}{x(x+2)}$

3 $(x^2 + 10) / (x^2 + 4x -5)$

4 $(x^2 – 3x - 10) / (x^2 + 8x + 36)$

5 $\frac{y}{20-3x}$

Activity sheet 9

Multiplication and Division of Fractions

To solve problems in algebraic fraction involving multiplication and division, you are required to factorise fully first, then divide the numerator and denominator by any factor which they have in common.

Example 1

Simplify $(a^2 + 2a - 3)/(a^2 - 16) \times (a + 4)/(a2 + 8a + 15)$

$(a^2 + 2a - 3)/(a^2 - 16) \times (a + 4)/(a2 + 8a + 15)$

$= \frac{(a+3)(a-1)}{(a-4)(a+4)} \times \frac{a+4}{(a+5)(a+3)}$ factorise given expression

$= \frac{a-1}{(a-4)(a+5)}$

Example 2

Simplify $(m^2 - a^2)/(m^2 + bm + am\ ab) \div (m^2 - 2am + a^2)/(cm + bc)$

To divide by a fraction, simply multiply it by its reciprocal

$(m^2 - a^2)/(m^2 + bm + am\ ab) \div (m^2 - 2am + a^2)/(cm + bc)$

$= (m^2 - a^2)/(m^2 + bm + am\ ab) \times (cm + bc)/(m^2 - 2am + a^2)$

$= \frac{(m-a)(m+a)}{(m+b)(m+a)} \times \frac{c(m+b)}{(m-a)(m-a)}$

$= \frac{c}{(m-a)}$

Activities

Simplify the following

1 $\frac{18ab}{15bc} \times \frac{20cd}{24de}$

2 $\frac{m+n}{m} \times \frac{mn}{3m+3n}$

3 $\frac{2a-2b+2c}{8bc} \times \frac{10abc}{5a-5b-5c}$

4 $(e^2 - 5e + 6)/(e^2 + 2e - 3) \div (3e - 9)/(2e^2 - 6e)$

5 $(3d^2 - 12)(9d^2) \times (6d^3)/(4d + 8)$

Activity sheet 10

Arithmetic Progression

A sequence in which the terms either increase or decrease in equal quantity is called an Arithmetic Progression. The sequence 9, 12, 15, 18, 21, . . . has a first term of 9 and a common difference of 3 between the terms.

The nth Term of an AP

If Un denote the nth term of a sequence, then:

$Un = a + (n - 1)d$

This pattern can be shown by observing the pattern of the terms in the general AP:

1^{st} term = a

2^{nd} term = a + d

3^{rd} term = a + 2d

4^{th} term = a + 3d

5^{th} term = a + 4d

nth term = a + (n - 1)d

Where a = first term and

d = common difference between the terms.

Example 1

Given the AP: 9, 12, 15, . . . find its 8^{th} term

In the AP,

The first term, a = 9

The common difference, d = 3

$U_8 = a + (8 - 1)d$

$= 9 + 7 \times 3$

$= 9 + 21$

$= 30$

The 8^{th} term of the given sequence is 30

Example 2

The 43^{rd} term of an AP is 26. Find the first term of the progression, given that its common difference is $\frac{1}{2}$.

From the given data,

$U_{43} = 26$, $d = \frac{1}{2}$, $n = 43$

$U_{43} = a + (n - 1)d$

$: 26 = a + (43 - 1)\frac{1}{2}$

$26 = a + 42 \times \frac{1}{2}$

$26 = a + 21$

$a = 5$

Activities

1 Find the 9th term of the AP: $3\frac{1}{4}$, $5\frac{1}{2}$, $7\frac{3}{4}$, 10, . . .

2 The 18th term of an AP is 25. Find its first term if its common difference is 2

3 The first and last terms of an AP are 6.7 and 17.1 respectively. If there are 14 terms in the sequence, find its common difference.

4 Find the number of terms in an AP given that its first and last terms are a and 37a respectively and that its common difference is 4a.

Activity sheet 11

Arithmetic Progression

A sequence in which the terms either increase or decrease in equal quantity is called an Arithmetic Progression. The sequence 9, 12, 15, 18, 21, . . . has a first term of 9 and a common difference of 3 between the terms.

Sum of an Arithmetic Series

The sum of Arithmetic progression is given by:

Sn = $\frac{1}{2}$n$[a + l]$ or

Sn = $\frac{1}{2}$n$[2a + (n - 1)d]$

Where; a = first term

d = common difference

l = last term

Example 1

Find the sum of the first 20 terms of the AP: 16 + 9 + 2 + (- 5)+ . . .

a = 16, d = - 7, n = 20

Sn = $\frac{1}{2}$n$[2a + (n - 1)d]$

Sn = $\frac{1}{2} \times 20[2 \times 16 + (20 - 1) - 7]$

Sn = - 1010

Example 2

The salary scale of a worker starts at N5 700 per annum. A rise of N280 is given at the end of each year. Find the total amount of money that the worker will earn in 14years.

1st year salary = N5 700

2nd year salary = N5 980

And so on, adding N280 each year

Total earning in 14 years

= N5 700 + N5 980 + . . . for 14 years

This is an AP with;

a = 5 700, d = 280 and n = 14

It follows that

Sn = $\frac{1}{2}$n$[2a + (n - 1)d]$

$S_{14} = \frac{1}{2} \times 14[2 \times 5\,700 + (14 - 1)280]$

= 7(11 400 + 13 × 280)

= 7(11 400 + 3640)

$= 7 \times 15\ 040$

$= 105\ 280$

The worker will earn a total of N105 280 in 14years.

Activity

1 Find the sum of all the multiples of 9 between 0 and 200.

2 The first and last term of an AP are 1 and 121 respectively. Find

i) the number of terms in the AP and

ii) the common difference between the terms if the sum of the terms is 549

3 the salary scale of a clerical officer starts at N2 300 per annum. A rise of N150 is given at the end of each year. Find the total amount of money earned in 12 years.

Activity sheet 12

Geometric Progression

A sequence in which the terms either increase or decrease in a common ratio is called a Geometric Progression. The sequence 5, 10, 20, 40, . . . has a first term of 5 and a common ratio of 2.

The nth term of a geometric progression

The nth term of a GP is given by Un where

$U_n = ar^{n-1}$

This can be shown by observing the terms in the general GP:

1^{st} term = a

2^{nd} term = ar

3^{rd} term = ar^2

4^{th} term = ar^3

5^{th} term = ar^4

n^{th} term = ar^{n-1}

Example 1

Given the geometric progression 5, 10, 20, 40, . . . find its 9^{th} term.

In the GP,

The first term, a = 5

The common ratio, r = $\frac{10}{5} = \frac{20}{10} = 2$

$U_n = ar^{n-1}$

$U_9 = ar^{9-1}$

$= 5 \times 2^8$

$= 5 \times 256$

$= 1280$

Example 2

The first, second and last terms of a GP are 162, -108 and $-21\frac{1}{3}$ respectively. Calculate the number of terms in the GP.

Common ratio = $-\frac{108}{162} = -\frac{2}{3}$

Using $U_n = ar^{n-1}$

$21\frac{1}{3} = 126 \times (-2/3)^{n-1}$

$(-2/3)^{n-1} = (21\frac{1}{3})/162 = (-64)/(3 \times 162)$

$(-2/3)^{n-1} = (-2/3)^5$

$\because n - 1 = 5$

$n = 6$

There are 6 terms in the GP.

Activities

1 The 8th term of a GP is $-\frac{7}{32}$. Find its common ratio if its first term is 28.

2 The 6th term of a GP is 200. Find its first term if its common ratio is 10.

3 A GP has a first term a, a common r and its 6th term is 768. Another GP has a first term of a, a common ratio of 6r and its 3rd term 3456. Evaluate a and r.

Activity sheet 13

Sum of Geometric Progression

A sequence in which the terms either increase or decrease in a common ratio is called a Geometric Progression. The sequence 5, 10, 20, 40, . . . has a first term of 5 and a common ratio of 2.

The sum of a geometric progression is given by

$$S = \frac{a(1 - r^n)}{(1 - r)} \quad \text{when } r < 1 \text{ or}$$

$$S = \frac{a(r^n - 1)}{(r - 1)} \quad \text{when } r > 1$$

Examples

1 Find the sum of the geometric progression 2 + 6 + 18 + 54 + . . . 1458

2 + 6 + 18 + 54 + . . . 1458

First term, a = 2

Common ratio, r = 6/2 = 18/6 = 3

Last term, $ar^{n-1} = 1458$

:. $2 \times 3n - 1 = 1458$

$3^{n-1} = 729 = 3^6$

n – 1 = 6

n = 7

Using $S = \frac{a(r^n - 1)}{(r - 1)}$

$= \frac{2(3^7 - 1)}{(3 - 1)}$

$= \frac{2(2187 - 1)}{2}$

= 2186

Example 2

A GP has 6 terms. If the 3rd and 4th terms are 28 and -56 respectively, find

a) the first term

b) the sum of the GP

a) the 3rd term, $ar^2 = 28$ (i)

the 4th term, $ar^3 = -56$ (ii)

(ii) ÷ (i) : r = -2

Substitute -2 for r in (i)

$a(-2)^2 = 28$

a = 7

The first term of the GP is 7

b) Using $S = \frac{a(r^n - 1)}{(r - 1)}$

$$S = \frac{7[-2^6 - 1]}{-2-1}$$

$$S = \frac{7[64 - 1]}{-3}$$

$$S = \frac{7 \times 63}{-3}$$

$$S = -147$$

The sum of the GP is -147

Activities

1 Calculate the sum of the GP: 45 + 30 + 20 + . . . to the 6^{th} term

2 A GP has 8 terms. Its first and last terms are 0.3 and 38.4. Calculate the sum of the geometric progression.

3 The 2^{nd} and 5^{th} term of a GP are -7 and 56 respectively. Deduce the sum of the first five terms.

Appendix F

Jigsaw I Learning Strategy Manual

The jigsaw technique is a method of organizing classroom activity that makes students dependent on each other to succeed. It breaks classes into groups and breaks assignments into pieces that the group assembles to complete the (jigsaw) puzzle. Just as in a jigsaw puzzle, each piece; each student's part is essential for the completion and full understanding of the final product.

The technique splits classes into mixed groups to work on small problems that the group collates into a final outcome. For example, an in-class assignment is divided into topics. Students are then split into groups with one member assigned to each topic. Working individually, each student learns about his or her topic and presents it to their group. Next, students gather into groups divided by topic. Each member presents again to the topic group. In same-topic groups, students reconcile points of view and synthesize information. They create a final report. Finally, the original groups reconvene and listen to presentations from each member. The final presentations provide all group members with an understanding of their own material, as well as the findings that have emerged from topic-specific group discussion.

Benefits

Jigsaw is a well-established method for encouraging group sharing and learning of specific content. This technique can be used as an instructional activity across several days and is best to use when there is a large amount of content to teach.

Jigsaw helps students learn cooperation as group members share responsibility for each other's learning by using critical thinking and social skills to complete an assignment. Subsequently, this strategy helps to improve listening, communication, and problem-solving skills. Monitoring each student's participation within the groups provides teachers with information about how much the students already know about the topic. This allows teachers to tailor instruction accordingly.

Creating the strategy

1. Introduce the technique and the topic to be studied.
2. Assign each student to a "home group" of 3-5 students.
3. Task Division. Divide the topic into four sub-topics.
4. Provide materials and resources necessary for all students to learn about their topics and become "experts".
5. Give all students a framework for managing their time on the various parts of the jigsaw task.
6. Expert Group Meeting. Students with the same subtopic meet to learn about their topic and discuss ways to teach it to others. Teacher provides guiding questions. (Note: This would be attached).
7. Provide key questions to help the "expert groups" gather information in their particular area.
8. Reassemble as Home Groups. Each expert teaches his/her subtopic.

During this process teachers should:

1. circulate to ensure that groups are on task and managing their work well;
2. ask groups to stop and think about how they are checking for everyone's understanding and ensuring that everyone's voice is heard; and monitor the comprehension of the group members by asking questions and rephrasing information until it is clear that all group members understand the points.

Remind students that "home group" members are responsible to learn all content from one another.

Appendix G

Summary of Students' Performance in Mathematics in SSCE in Kaduna state from 2011-2015

Year	No of students registered	Students with credits(Percentage)	Students with pass(Percentage)	Students with F9 (Percentage)
2011	43,329	6,100 (2.6%)	6,932 (15.9%)	35,292 (81.9%)
2012	29,492	2,302 (7.8%)	10,478 (35.5%)	16,712 (56.7%)
2013	37,935	7,053 (18.6%)	22,421 (59.1%)	8,461 (22.3%)
2014	21,251	816 (3.8%)	8,268 (38.9%)	12,167 (57.3%)
2015	31,481	4,142 (13.1%)	10,464 (33.3%)	16,875 (53.6%)

Source: Kaduna Education Resource Department, (2016)

Appendix H

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT (r) OF PILOT TEST SCORE FOR SAAS

S. No.	1st Score (X)	2nd Score (Y)	X^2	Y^2	XY
1	1	2	1	4	2
2	2	2	4	4	4
3	3	3	9	9	9
4	2	2	4	4	4
5	1	2	1	4	2
6	2	3	4	9	6
7	3	3	9	9	9
8	2	2	4	2	4
9	4	4	16	16	16
10	4	3	16	9	12
11	2	4	4	16	8
12	3	3	9	9	9
13	2	3	2	9	6
14	1	2	1	4	2
15	1	2	1	4	2
16	2	3	4	9	6
17	1	2	1	4	2
18	2	3	4	9	6
19	3	4	9	16	12
20	4	4	16	16	16
21	1	1	1	1	1
22	2	3	2	9	6
23	1	2	1	4	2
24	1	2	1	4	2
25	2	1	4	1	2
Total	**52**	**62**	**132**	**172**	**144**

$$r = \frac{\sum XY - \frac{1}{N}\sum X \sum Y}{\sqrt{(\sum X^2 - \frac{1}{N}(\sum X)^2)(\sum Y^2 - \frac{1}{N}(\sum Y)^2)}}$$

$$r = \frac{175 - 158}{\sqrt{(148 - 120)(225 - 208)}}$$

$$r = 0.853$$

$$r \simeq 0.85$$