IMPACT OF INQUIRY-DEMONSTRATION METHOD ON REMEDIATING NEWMAN ERRORS AND ENHANCING PERFORMANCE IN ALGEBRA AMONG SENIOR SECONDARY SCHOOL STUDENTS, KADUNA STATE, NIGERIA.

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APPROVAL PAGE

This Dissertation entitled “Impact of Inquiry-Demonstration Method on Remediating Newman Errors and Enhancing Performance in Algebra among Senior Secondary School Students, Kaduna State, Nigeria” by Sulaiman Ibn ALHASSAN, Med/P13EDSC8011, meets the regulations governing the award of degree of Masters in Mathematics Education of Ahmadu Bello University, Zaria, and approved for its contribution to knowledge and literary presentation.

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DECLARATION

I declare that the work in this Dissertation entitled "Impact of Inquiry-Demonstration Method on Remediating Newman Errors and Enhancing Performance among Senior Secondary School Students, Kaduna State, Nigeria" has been conducted by me in the Department of Science Education, Ahmadu Bello University Zaria. The information obtained from related literature was dully acknowledged in the text and list of references provided. No part of this Dissertation was previously presented anywhere and in any form.

Sulaiman Ibn ALHASSAN	Signature	Date

DEDICATION

This Dissertation is dedicated to my Mother; Amina Al-hassan my late father Malam Al-hassan bakadamu kowaba kaya may his gentle soul rest in perfect peace, my beloved wives Fatimah and Hauwau including all our children and entire family of Al-hassan bakadamu kowaba.kaya.

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LIST OF ABBREVIATIONS

N.O.U.N	-	National Open University of Nigeria
N.C.T.M	-	National Council of Teachers of Mathematics
D.P.R.S	-	Directorate of Planning Research and Statistics
Q.E.N.E.D.T	-	Quadratic Equation Newman Error Diagnostic Test
Q.E.P.T	-	Quadratic Equation
M.N.I.S	-	Modified Newman Interactive Schedule
N.E.D.T	-	Newman Error Diagnostic Test
N.E.R.D.C	-	National Educational Research and Development Council
M.A.N	-	Mathematical Association of Nigeria
S.T.A.N	-	Science Teachers Association of Nigeria
M.M.N.S	-	Manual of Modified Newman Interactive Schedule

OPERATIONAL DEFINITION OF TERMS

Inquiry-Demonstration Method: Is an instructional strategy that follows a laid down procedures or steps set by the teacher in presenting problems to students, through demonstration by the use of prepared materials.

Remediating: Remediation is defined as an attempt by a teacher to address deficiencies in students learning to prevent them from falling behind in their education. It also refers to the correction of the mistakes or errors committed in the solution process of quadratic equation.

Newman Errors: Are six different types of errors in the solution process equation in algebra. They are reading errors, comprehension errors, are reading errors, transformation errors, process skill, encoding errors and carelessness errors.

Performance Is the quality of results produced by students as reflected in the quality of their examination scores in quadratic equation.

Performance is also defined as the level of accomplishment of school educational objectives.

ABSTRACT

This study assessed the impact of inquiry-demonstration method on remediating Newman errors in quadratic equations and enhancing performance in algebra among senior secondary students in Kaduna state. The research design was survey and quasi-experimental in nature. Diagnostic test for Newman errors identification was surveyed while; the remediating part was in form of quasi-experimental in nature. Pre-test posttest experimental and control group design was adopted. Two Co-educational schools were selected out of twenty senior secondary schools in the zone. 186 students made up of 113 males and 73 females out of 3,606 senior secondary school students were randomly selected as sample size and used for the study. Four research questions and four hypotheses were formulated and assessed using descriptive statistics of frequency and percentage to answer research questions 1, 2 and 3. Mean and standard deviation was used to answer research question four. Chi-square statistics was used to test null hypotheses 1, 2 and 3 and t-test statistics was used to test null hypothesis 4, ANOVA was used to test the significant difference among schools and Schaffer's was used to test those schools that were not significant as sample schools, at $P \leq 0.05$ level of Significance. Three instruments were used, Quadratic Equation Error Diagnostic Test (QEDT), Quadratic Equation Performance Test, and Modified Newman Interactive Schedule (MNIS) to measure the Newman errors, Performance as well as conducting an interactive schedule. Test retest reliability was observed. Pearson Product-Moment Correlation Coefficient (PPMCC) Statistics of the instruments was used to estimate the reliability coefficients and calculated to be 0.88 and 0.75 respectively. The difficulty and discriminating indices were found to be 0.80, and 0.71. The findings showed that there was significant difference in the frequencies of Neman errors of experimental and control groups, the inquiry-demonstration method of teaching was not gender friendly on Newman errors and performance. It is recommended that provision of in-service training on the effective use of inquiry-demonstration method in the teaching and learning processes of quadratic equation in algebra be granted to teachers, to minimize the Newman errors and improve students' performance in mathematics, the concepts of quadratic equations in algebra should be taught effectively in order to reduce the frequencies of Newman errors and improve students' performance. Professional bodies such as MAN, STAN, Mathematics educators, Text books publishers should organize training programs for teachers teaching mathematics in form of seminars, workshops and conferences focusing on the effective use of inquiry-demonstration method as an instructional strategy in the teaching and learning of the concepts of algebra in mathematics.

CHAPTER ONE

1.1 Introduction THE PROBLEM

Mathematics is the bedrock of all sciences; hence, recognition attached to mathematics cannot be over emphasized. Mathematics is the basic knowledge required by students to extend their learning to a higher level. Not only that, it is also required for our daily lives, irrespective of educational background and social life. The benefit derived from mathematics is not only restricted to knowledge acquired in computations, but more importantly, when each individual can master it very well. It is then that the pattern of reasoning will be more rational and critical. Principle of mathematics enables people to see the problems as facts but not as a fiction Hudoyo and Itanku, (2005).

National Council of Teachers of Mathematics NCTM (2006) has emphasized that mathematics is a science of size and numbers, logical reasoning and model thinking that constitutes everyday activities (Moore, 2005). This is due to the fact that mathematics provides the laws, the formulae and the theorems that empower the scientific and technological developments (Musa, 2006). However, mathematics became a major area of concern over the years, because large number of students failed their final examinations. Mathematics as a subject has occupied a sensitive place in school curriculum and plays a vital role in the development of any nation (Odili, 2006). Mathematical concepts are interrelated with one another. This is because learning process in mathematics is categorized as hierarchical. The mastery of basic mathematical knowledge is very essential in concept development. Mathematics has played fundamental role in the economic development of many countries of the world Popoola, (2007). Therefore mathematics has to be taught in a way that will make it learners-friendly by Practicalising its instruction using concrete

objects. He further stated that, instruction in mathematics reduces to a large extent the abstract nature of some mathematic concepts. Without a clear understanding of basic concepts and skills learned in the early stages, result in the learning will be more difficult at the subsequent stages (Liew & Wan in Effandi & Siti, 2010).

On the other hand, many mathematics classroom teachers are faced with the problem of choice of instructional methodologies that fit neatly not only the topics but also learners' conceptual understanding, since they realize that no one particular method of teaching is always suitable for every student (Bolaji in Olabisi, 2011). Mathematics has generally been accepted as a foundation of science and technology as well as many other disciplines such as Accounting, Business Administration, Transportation, Geography, Climatology, and Engineering among others (Okeke, 2011). The National Policy on Education (FRN, 2013), highlights that, Mathematics is one of the core subjects taught in secondary schools and tertiary institutions in Nigeria. It is defined as a body of knowledge which is concerned with the logical language of expressing ideas, shapes, quantities, sizes, other change and dynamic in the system, and for explaining the complexities of modern society in the business, economics, academic, engineering and medical setting. Mathematics is a major subject required at credit level before proceeding to advanced level in Nigeria. The goal of mathematics education reform which is to produce students who are skilled in resolving problems in addition to fostering attitudes, interests and a high motivation towards mathematics should be strengthened to meet up with the demand. Students should be exposed to skills in interpreting problems, planning of solution strategy, implementation of plan and rechecking of solutions. In order for the students to think mathematically, they need to be exposed to various teaching strategies that include inquiry-demonstration, deductive, inductive among others method following each step carefully and systematically.

Lecture Method is the traditional method of transmission of knowledge to learners characterized as a one-way passive the method is the most frequently used method of instruction (Suleiman, 2011). It is a traditional method of teaching defined as a teaching technique in which one person, usually the teacher, presents a spoken discourse on a particular subject (Aminu, 2011). It emphasizes "Talk and Chalk" in the teaching of Mathematics it is indeed an oral presentation intended to present information or teach people about a particular subject. It conveyed critical information, historical background, theories and equations Donald (2011). According to Okeke, (2011) mastery of basic Mathematical knowledge is essential in concept development. Mathematics is the basic knowledge required by students to extend their learning to a higher level. Not only that, it is also required for our daily lives, irrespective of educational background and social identities.

Inquiry Method is defined as a pseudo-experiment, where the teacher has the student reify already taught concepts. The part of the lesson's thought matched the different components and is revised at each stage to allow for proven questions by students. It is a highly interactive step-by-step approach which involved the students at all levels of discussion. It is a teaching strategy which follows a systematic laid down principle which is set by the teacher, for easy comprehension by the students (Obeka, 2010). On the other hand, Demonstration Method is a method of teaching in which sight rather than hearing is the major means of communication. Though, the two are often combined. It is often effective because, most people more easily remember what they see than what they only hear or read about. It is a method whereby the teacher illustrates with demonstration and relevant examples, of all the concepts involved in a given lesson (Obeka, 2010).

There are numerous types of inquiry models of teaching used. Experimental factor can be used to understand the concept of Mathematics effectively, with the students dominating in the

discussion. These models are inductive inquiry, inquiry demonstration, deductive inquiry and problem solving. "Inquiry is the way people learn when they're left alone." Inquiry is the natural way that human beings learn about their environment. Think for a moment about a very young child left in a play yard with objects free to explore (Suchman in Mujibul, 2008). The child, without any coaxing will begin to explore the objects by throwing, touching, pulling, banging them, and trying to take them apart. The child learns about the objects, and how they interact by exploring them, by developing his or her own ideas about them in short this is learning by inquiry. Dewey (2013) proposed that inquiry is the "active persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions convey critical to which it tends. The ground of "any belief" occurs through inquiry processes: reason, evidence, inference and generalization (Sola & Ojo, 2013).). Teachers should not focus only on fact errors, but also on basic errors, especially when learners are making the same procedural errors (Gernett, 2007; Stein et al., 2007). National Examination Commission (NECO, 2006 & 2007) showed that student's results in Zaria Educational Zone for the subject of Mathematics is still low. West African Examination Council (WAEC, 2014 & 2015) in the same zone also shows that the performance of students in mathematics was low and the target has not been achieved. A report in one of the Nigerian News Dailies by Federal Ministry of Education indicated that methods of teaching and quality of delivery of teachers came first among the problems affecting in the education sector in Nigeria leading to poor performance in mathematics. The WAEC (2010) Chief Examiners Report revealed persistent failure in mathematics and candidates' lack of skill in answering almost all the questions asked in algebraic processes. It also reported candidates' weakness in algebraic expression and word problems among others, leading to poor attitude of students towards the subject. It was also observed by the WAEC Chief

Examiners (2013) that some questions at the SSCE are difficult areas for students, an indication that the topics, from which the questions were set, may not have been taught well by the teacher.

Inquiry-demonstration method was defined as a method of presenting a problem to students. The demonstration is not designed to illustrate a concept or principle of science it is instead designed to present a discrepancy or problem for the students to explore (Suchman in Mujibul, 2008). An inquiry session is designed to engage the class in an exploration of a problem staged by means of the discrepant event. An inquiry session begins with the presentation of a problem through demonstration. Description of the problem will be posed to the students by the use of prepared materials. These include materials from texts, reference books prepared on quadratic equations. The students will be required to apply different skills in solving problems that affect the three components under consideration in this study. That is factorization, completing the square and quadratic formula method. The researcher intended to use the method in order` to study all the students during the inquiry-demonstration session towards improving their performance in the subject matter, that is, 'quadratic equation' and mathematics in general. However, Suchman in Mujibul, (2008) did not take cognizance of the importance of introduction. Inquiry method is one of the models of teachings used for an effective learning whereby the students dominate the discussion. Examples include inductive inquiry, inquiry demonstration, deductive inquiry and problem solving.

Evaluating student's performance concerned with the process of determining the extent to which instructional objectives have been achieved (Bawa, 2014). Evaluating instruction help the teacher to know how effective his strategies are in terms of effective learning, and the results of such evaluation reveal to the learner how he is faring and helps to spur him into more serious

action (Guga, 2014). In view of the above supporting views by the authorities, the researcher wished to adapt the model of inquiry-demonstration.

Error in solving mathematical problem often occurs in writing, or orally. Students are usually faced with many obstacles during the process of solving problems. Problem solving in mathematics is a skill that is very complex Hudoyo and Nakamura, (2014). Sometimes students know how to answer questions stated, but due to carelessness in computation they failed to arrive at the answer correctly. This shows that mastery of mathematics among the students is still weak. The weakness may be attributed to the learning process that focuses more on rote learning, involves less group work, interaction and communication. There are different models of errors identifications by different authorities. These include; Procedural errors, Fact errors, Basic errors, Newman errors, Conceptual errors, Ashlock errors, Suydam errors etc. Salwa (2014) observed that classification of errors varies from individual to individual. That no two specialists would agree on the exact way of classifying some errors and it is a waste of time to research for an ideal method. In consideration of the above different types of errors by different authorities this study will be based on Newman error hierarchy model only. Error has since been discussed long time ago in the 17^{th} century for instance (Bacon, & Pierce in Luneta, 2014) states that most of the teachers identify learners' errors but rarely diagnose them. He further stated that when analyzing and diagnosing errors learners displayed, we identify the root cause of those errors and how best they can be corrected for the benefit of both the learners and the teachers.

Errors derived from procedural knowledge is the inability of learner to use the relevant procedures in solving mathematical problems by following the rules, method and procedures in different representations (Hilbert, Lefebvre & Isik, in Kanyaliglue & Ipek 2015). Procedural knowledge is a particular type of learning, displaying solved problems and also adhering to certain

instructions when completing different types of problems. Luneta (2014) asserted that procedural knowledge is specific to a particular task, and this implies that some procedures are not appropriate to solve certain mathematical problems. Learners may grasp relevant procedures but fail to use them correctly in solving mathematical problems (Siegler, 2003). Learners who lack this understanding are frequently using wrong procedures and this generates systematic pattern of errors in solving problems.

The model has proved to be a reliable model for mathematics teachers. The framework has six types of errors: Reading error, comprehension, transformation, process skill, encoding error and carelessness. The Newman error Hierarchy model is suitable to be used in identifying students' error in mathematics. The model has the Hierarchy that classifies types of error based on the problem solving level done by the students. According to Clement and Ellenton (2014), Newman used the word" hierarchy" because she reasoned that failure at any level of sequence prevents students from obtaining satisfactory solutions. Prakitipong and Nakamura (2014) pointed out that, in the process of problem solving there are two kinds of problems that hinder students from arriving at correct answer: these are Problem in linguistics fluency and conceptual understanding that correspond with level of simple reading and understanding meaning of the problems. Another problem is that of mathematical processing which require skills applications.

Musa (2010) defined performance as the quality of results produced by students as reflected in the quality of their examination score. Azuka (2006) defined academic performance as the level of accomplishment of school educational goals by students over a stipulated time. He added that poor performance of students in mathematics is attributed to the lack of teaching materials, mathematics phobia, poor teaching facilities that include equipments and instructional materials

for effective teaching. Adediwura, (2007) defined academic performance as the display of knowledge attained or skills developed in school subjects designated by test and examination scores or marks assigned by the subjects teachers. James (2015) declared that academic performance really involved knowing how much a student has learned. One way by which this can be determined is by the use of achievement test. Achievement test can give students an indication of his progress and acts as a reward for his effort or as spur against under achievement. It also indicates to the teacher the importance placed by the teacher on the various things that are taught.

Remediation refers to the correction of the mistakes or errors students commit in the solution process of quadratic equation. In addition remediation refers to an attempt by a teacher to address any deficiencies in students learning to prevent students from falling behind in their education. If a student does not know how to multiply numbers then he cannot solve equation in a later unit (Riccomini & Hansen, 2006). In addition before a student reaches this point of failure, the teacher must identify the problem and help the students to master the problems. Because mathematics concept builds upon each other, remediation holds the key to any successful mathematics classroom. Problems which students have in the learning process include among others phobia, anxiety, and Newman errors. The researcher therefore studied the Newman errors students committed in the learning process of quadratic equations. There are different approaches to Newman errors remediation these include: Formative Assessments, Exit formative assessments test, Remediation plan, Matching remediation to students needs, Technology, Problem solving, Inquiry method, Demonstration method, Inquiry-demonstration method, Inductive method, Deductive method etcetera. In formative assessments, a teacher uses a regular formative assessment in order to identify learning deficiencies in a mathematics classroom. Teacher uses different formative assessments including exit quizzes, one-on-one explanation and written

explanations (Reccomini, 2006). This study therefore used inquiry-demonstration method to remediate these Newman errors.

Exit formative assessment test requires a teacher to test the skills taught on a given day and is presented to the students before they leave the classroom. For example, after teaching students how to solve an equation for "x" the teacher puts the equation on the board and requires the students to solve the problem to the best of their abilities, (Riccomini, 2006). Having seen different approaches to the problems remediation in mathematics, the researcher will employ the use of inquiry-demonstration method in order to remediate students errors committed in the learning process of quadratic equations using factorization, completing the square and formula methods. Riccomini and Hansen (2006) defined errors as the mistakes learners make when solving problems that may be caused by carelessness, misinterpretation of symbols or text, lack relevant experience or knowledge related to that mathematical topics, learning objectives, concept, lack of awareness or ability to check the answers given. The outcomes of the written students' work in their test were evaluated according to the type of error in Newman Error Hierarchy model. Student who failed the written test were re-examined using the modified Newman interview procedure. So that if the student was able to get the answer correctly, it implies that the error he/she committed in the written test was as a result of carelessness. If the error is committed again the student will be taken through all the interview process.

Quadratic equation is a branch of algebra that comprises of four different components required in finding the roots of quadratic equations, applying different skills. In other words roots of the equations are obtained using any one of the four methods viz; Factorization method, completing the square method, formula method and graphical method. The four methods were considered for this study. This is because students commit Newman errors in all the four methods

factorization, completing the squares, quadratic formula and graphical methods in finding the roots of quadratic equations, which is in line with WAEC chief examiners reports of 2003; 2005 and 2008, which highlighted areas of students' weakness that lead to the frequent poor performance.

Factorization method in quadratic equation is one of the four approaches in evaluating the roots of a given quadratic equation. Factorization is the decomposition of an object, or factors, which when multiplied together give the original. For example the number 15 can be factored into primes as 3 x 5, and the polynomial $x^2 - 4$ factors as (x-2)(x+2). In all cases, a product of simpler objects is obtained. Completing a square method in quadratic equations is a method of solving quadratic equations which is helpful if applied appropriately in finding the solutions to the equations. Students need to be encouraged to apply the concept accordingly in order to provide correct answers. Laridon et al (2010) stated that in completing the squares learners should ensure that the coefficient of x^2 is 1 and if it is greater than or less than 1, students should divide by that coefficient, $ax^2 + bx + c = 0$. Students should divide by a throughout before they could find the additive inverse of both sides to have $x^2 + \frac{b}{a}x + (\frac{b}{a})^2 = -\frac{c}{a} + (\frac{b}{a})^2$. Students can then add half the coefficient of x to both sides of the equation before the equation could be factorized, $x^2 + (\frac{b}{a})x + (\frac{b}{a})^2 = -\frac{c}{a} + \left(\frac{b}{a}\right)^2$ The equation can then be factorized on the left hand side and be simplified on the right hand side (Pretoria's et al., 2006). Clarkson (2007) found that comprehension error makes up a high proportion of the errors makes when students attempt to solve mathematical word problems leading to quadratic equations. However, Noraisiah (2008) found that most students in her study made comprehension and process skill error. In addition process skill error was found to be the most common error committed by the students in the process of solving problems in quadratic equation. Quadratic formula method of solving quadratic equations is a method that is used to find the roots of quadratic equation (Luca, 2012).

James (2015) declared that academic performance really involved knowing how much a student has learned. One way by which this can be determined is by the use of achievement test. Achievement test can give students an indication of his progress and acts as a reward for his effort or as spur against under achievement. It also indicates on the importance to the teacher. Annemie and Martin (2011) stated that the term performance is used in parallel to other concepts, such as achievement, outcome, result, output, productivity and many others. Often, there are connotations and denotations linked to these terms. Performance refers to student's outcomes in mathematics test scores as measured with a specific instrument and neglects the full complexity of the processes involved in resulting to a particular score. There were various studies carried out to identify the causes of poor performance in mathematics and how poor performance in mathematics affects other areas of knowledge among others as identified by Inegwe in Falalu, (2015), the following are the factors responsible for the poor performance of students in mathematics.

- The relationship between the pupil and their teachers.
- The attitude of the teachers towards mathematics.
- Lack of sufficient and experienced teachers.
- Truancy on the part of some teachers and students.
- Lack of interest by some of the teachers and students resulting to absent mindedness.
- Indiscipline and poor mathematical background.
- Lack of laboratories and teaching aids.
- Large class which hinders effective supervision.
- Text books are foreign.
- Lack of guidance, language and wrong information, e.t.c

1.2 Statement of the Problem

This study intended to find the impact of Inquiry-Demonstration method on remediating Newman errors in algebra and performance among senior secondary students in Kaduna state, Nigeria. Research findings in secondary schools have shown that algebra is one of the difficult areas in mathematics which has become a major area of concern over the years. This was as a result of different types of error students commit which led to poor performance. They include Newman errors, procedural errors, fact errors, basic errors, conceptual errors, Aslock errors, Suydam errors among others. However, the researcher used Newman errors. The classification of these errors varies from individual to individual as observed by Salwa (2014). Prakitipong and Nakamura (2014) pointed out that, in the process of problem solving there are two kinds of problem that hinder students from arriving at correct answers as identified in the previous discussions.

During the process of teaching and learning of mathematics, students are bound to face a lot of problems, because it is a skill that is very complex (Effandi, Ibrahim & Siti, 2014). Sometimes students know how to solve problems given to them, but seem to be careless in computation, which shows that mastery of mathematics among students in Nigeria is still weak. The weakness may be due to the learning process that focuses more on rote learning as was earlier mentioned. This prompted the need to investigate whether inquiry-demonstration method has implication in remediating Newman's error in quadratic equation and performance among senior secondary students in Kaduna state.

1.3 Objectives of the Study

The major objective of this study is to assess the impact of inquiry-demonstration method on remediating Newman's error and enhancing performance in algebra among senior secondary students in Kaduna state Nigeria. However, the specific objectives of the study are to:

1. find the frequencies of Newman Errors committed by students in the solution process of quadratic equation among senior secondary schools;
2. examine the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method;
3. assess the frequency of Newman errors committed by male and female students in the solution process of quadratic equations exposed to inquiry-demonstration method;
4. determine the impact of inquiry-demonstration on students performance in quadratic equations among senior secondary students;

1.4 Research Questions

The study is set to answer the following research questions:

1. What is the difference in the frequencies of Newman errors committed by students in the solution process of quadratic equation among senior secondary schools?
2. What is the difference in the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method?

3. What is the difference in the frequency of Newman errors committed by male and female students in the solution process of quadratic equations exposed to inquiry-demonstration method?
4. What is the difference in the performance of students in quadratic equations exposed to inquiry-demonstration strategy and those exposed to lecture method?

1.5 Null Hypotheses

To guide the study the following null hypotheses were formulated and tested at $P \leq 0.05$.

H_{O1}: There is no significant difference in the frequencies of Newman errors committed by students in the solution process of quadratic equations among senior secondary schools.

H_{O2}: There is no significant difference in the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method.

H_{O3}: There is no significant difference in the frequency of Newman errors committed by male and female students in the solution process of quadratic equations exposed to inquiry-demonstration method.

H_{O4}: There is no significant difference in the performance of students exposed to inquiry-demonstration strategy and those exposed to lecture method.

1.6 Significance of the Study

The findings of the study would improve the standard of mathematics education in relation to the following ways:

- Mathematics teachers

- Mathematics Students
- Curriculum Planners
- Professional Bodies
- Text Books Publishers
- Researchers
- States and Federal Ministries of Educations etcetera.

Mathematics has been considered as one of the pre-requisite subjects in the general education world over. Mathematics features prominently in the school system from pre-primary to post-primary levels. This study will be significant if the findings will raise the standard of mathematics in the following ways: The results of the study would benefit the students in a number of ways such as in the ability to make use of the new technique in minimizing Newman errors usually committed in the learning process of quadratic equation and mathematics in general; elimination of Mathematics phobia and anxiety at the point of problem solving; Freedom to ask questions at each stage of teaching and in group discussions towards improving their performance in mathematics and ability to formulate theories during classroom teaching and learning situation. The result of the study would help teachers to make effective use of inquiry-demonstration method in teaching the subject mathematics, in accordance with the student's level of understanding. This will help teachers to make careful comparison between the conventional method of instruction and experimental method, otherwise known as scientific method of teaching. Teachers of mathematics will acquire a world of experience, and ability to solve problems using different approaches.

The findings would help the professional organizations like, Mathematical Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN), and National Educational Research and Development Council (NERDC) who carryout researches, discussions and

disseminate research findings they might wish to consider the results of this study with a view of using the strategy to promote mathematics instructions in schools through appropriate seminars and workshops as the case may be. Curriculum designers who decide the syllabi and recommend effective methods of instruction may wish to consider the results of this study with a view of recommending it as a teaching strategy in schools where appropriate, towards improvement of mathematics teachers, by organizing workshops, seminars, and conferences on effective use of inquiry teaching method, in teaching of quadratic equation. Text book publishing organizations will find the results very useful in the design of activities that involve the application of inquiry teaching methods in their publications. Researchers in similar areas of the study will find the results very useful. So that they may adapt it for their own studies and can obtain additional knowledge by improving on the existing literature. Mathematics educators will find the result of the study very useful, to prepare more ideas which may be required, by the teachers during conference and seminars or for publications in journals and text books. Local, State and Federal Ministries of Education will find the research very useful, especially where the students' performance in mathematics remained poor as a result of the different types of Newman errors committed by the students in the process of solving problems in quadratic equations and mathematics in general.

1.7 Scope of the Study

The study would examine the impact of inquiry-demonstration method on remediating Newman errors and enhancing performance in algebra among senior secondary students in Kaduna state. The study will be delimited to public senior secondary schools in Kaduna state. The reasons for choosing public secondary schools can be attributed to their uniformity in socio-economic background, admission, promotion policy, staffing and availability of teaching materials. The study was also delimited to SSII Mathematics students in the study area. This level of students will

be used because they are considered stable for research than SSI Students that have just been registered. In addition, SSII have covered the SSI syllabus and are currently using SSII syllabus. The SSIII students excluded because they were about to write their SSS examination at the time of conducting the study. Topics covered in the study are factorization, completing the square, quadratic formula and graphical methods that require different skills in the process of solving problem. The topics were taught using inquiry-demonstration method to experimental group and the lecture method was used for the control group. This concept was selected for this study because mathematics curriculum prescribes its teaching at this level. In addition the concepts are the popular concepts in mathematics observed by researchers as areas of persistent problem.

Three instruments were used in the study. Two were designed by the researcher and adapted the third instrument. The instruments were used to evaluate the errors and performance that is Quadratic Equation Error Diagnostic Test (QEEDT) and Quadratic Equation Performance Test (QEPT). The former was used to diagnose the Newman errors committed by the students in the solution process of quadratic equation using different skills. On the other hand the latter was used to find the academic performance of the students in the solution process of quadratic equation. The scope of the instruments was delimited to the sampled schools and the pilot tested school in order to validate the instruments. Modified Newman Interactive Schedule (MNIS) was the third instrument used to carry out the interview for those students who failed the written test.

1.8 Basic Assumptions

The Study was based on the following assumptions that:

a. Senior secondary students (SSII) under the study have been committing Newman errors in the solution process of quadratic equation.

b. Teachers teaching mathematics in public senior secondary schools are familiar with inquiry- demonstration method.

c. The sample of the study is the representative of the population to whom inferences was made.

CHAPTER TWO

2.1 Introduction LITERATURE REVIEW

The purpose of this study is to assess the impact of inquiry-demonstration method on remediating Newman errors and enhancing performance in algebra among senior secondary students in Kaduna state, Nigeria. This chapter contains the review of some related literature of this study. The review was based on the various works related to inquiry-demonstration method of teaching, and their manifestations on students' performance in quadratic equation. The literature was reviewed as follows.

2.2 Theoretical Framework

The conceptual framework of this study was based on Newman Error Hierarchy Model, Modified Newman Interview and Suchmans' Inquiry-Demonstration method. However, the method of identifying the Newman errors and the procedure of inquiry session was stated against each type of Newman error and each of the procedures of inquiry session. The student's written test was evaluated according to the type of error in Newman Error Hierarchical Model (Newman, 1977 in Effandi & Siti, 2014). Newman used the word "hierarchy" because she reasoned that failure at any level of the sequence prevents students from obtaining satisfactory solution. The model has the hierarchy that classifies types of errors based on the problem solving level done by students. It was a reliable model used to identify six types of Newman errors by mathematics teachers. They include:

- **Reading Errors**: is the inability of the students to read the questions.
- **Comprehension Errors**: is the inability of the students to understand the questions.
- **Transformation Errors:** is the inability of the students to reduce what they understand into writing.
- **Process skill Errors**: is inability of the students to carryout the step by step solution process of the problem.
- **Encoding Errors**: is the inability of the students to arrive at the correct or wrong answers.
- **Carelessness**: is the ability of those students who failed the written test to answers the questions asked using modified Newman interview.

Modified Newman interactive schedule was purposely designed for those students who failed the written test, to find out why and how the Newman errors are committed by the students? The procedures include.

- Can you read the question? (Reading level)
- What does the question ask you to do? (Comprehension level)
- What do you use to solve the question? (Transformation level)
- Can you show the working steps that you have used to find the answer? (Process skill level)
- Tell me what is your answer? (Encoding level). Procedure of Suchmans Inquiry-demonstration method used in teaching the experimental group:

Rule 1: Questions.

Procedure 1**:** The question by the students should be phrased in such a way that they can be answered "yes or no". The burden of thinking will be left to the students.

- **Rule 2: Freedom to ask questions.**

  Procedure 2**:** A student may ask as many questions as desired once they begin. This encouraged the student to use his or her previous questions to formulate new ones to pursue a reasonable theory.

- **Rule 3: Teacher response to statement of theory.**

  Procedure 3: When students suggest a theory, the teacher should refrain from evaluating it. The teacher might simply record the theory, or ask a question about the student's theory.

- **Rule 4: Testing Theories.**

  Procedure 4: Students should be allowed to test their theories at any time.

- **Rule 5: Cooperation.**

  Procedure 5**:** Students should be encouraged to work in teams in order to confer and discuss their theories.

- **Rule 6: Experimenting.**

  Procedure 6: The teacher should provide materials, texts, reference books so that the students can explore their idea.

In this study, the experimental group was taught using (Suchman in Mujibul, 2008) inquiry demonstration method, in order to find the effects on remediating Newman's errors in quadratic equation and enhanced performance against those taught using lecture method.

2.3 Mathematics as a Teaching Subject at Senior Secondary Schools

Mathematics is an important subject taught at senior secondary schools. Abubakar (2007) states that students are ill equipped from senior secondary schools to handle mathematics problems, because they are poorly taught. He said that it is important that mathematics educators should work closely with the secondary school teachers in finding better alternative methods of teaching and learning mathematics. It is pertinent that mathematics has so much been emphasized worldwide and employed in all aspects of science, technology, engineering, communication and indeed virtually every aspect of life (Okeke, 2010). Mathematics has been defined differently by different authorities. Mathematics is defined as the science of quantity and space, mathematics is also seen as a subject that dwells so much on numbers (Odili in Yakubu, 2014). If these numbers are not applied to concrete objects they are being expressed in abstract terms. Mathematics is primarily concerned with ideas, processes and reasoning leading to the solutions of problems. Mathematics as a body of knowledge is made up of various branches. These include algebra, trigonometry, geometry and statistics (Hassan in Yakubu, 2014).

In spite of the importance of this subject especially in the post primary institution, students' performance in the subject is still low. Reports from West African Examination Council (WAEC, 2009, 2010) reported that students' performance was nothing to write home about. Other reasons attributed to the poor performance of in mathematics were as results of Newman errors committed by the students in the learning process of algebra in mathematics. These Newman errors include reading, comprehension, transformation, process skill, encoding and carelessness (Newman in Effandi & Siti, 2014). Problems associated with the failure of students in mathematics have been discovered by various researchers in various fields of mathematics, and mathematics education. Julie, (2013) attributed the problems to the lack of conceptual understanding. Other problems have to do with teachers such as, passive learners, memory problems, attention problems, cognitive and

meta-cognitive thinking deficits, low level of academic achievements, mathematics anxiety, teachers as facilitators and spiraling curriculum etcetera. These have continued to the major cause of concern to mathematicians and mathematics educators, thus necessitating further investigation on the impact of inquiry-demonstration method on remediating Newman errors and enhancing students' performance in algebra among senior secondary school students.

2.4 Historical Review of Algebra

Algebra with its historical representations is the bedrock of all branches of mathematics (Voyer & Bryden, 1995). Mathematics is important and necessary for the solution of life problems (Artique, Grugeon & Lifant, 2009). According to Witzer, Mercer and Miller, (2003), life is problem solving and invariably a function of mathematical reasoning and thinking. Artique et. al., (2009), assert that mathematics process is problem solving and all problems are resolved into algebraic expressions and equations for possible solutions. This implies that students who master and retain the knowledge and skills of algebra are likely to apply them successfully in real life situations. Despite the relevance of mathematics, the persistent high rate of failure in public mathematics examinations by senior secondary school students is an issue of great concern to Nigerians. In fact as Nigeria desires for scientific and technological advancement, there is need for a good achievement in mathematics at all levels of education especially at the senior secondary school level from where future Nigerian leaders are prepared for the tertiary level, (Aliyu, Lawal & Garba, 2013). Students' mass failure in mathematics has always been confirmed by the West African Examination council, Chief Examiner's reports (WAEC, 2011), revealed that the percentage of students who failed in mathematics at the Senior Secondary Certificate Examination was due to their poor attempt in algebra related questions. The reports states that only 10 percent recorded distinction. It was also reported that the four mathematical operations that is addition,

multiplication, subtraction and division that are the basics of algebra were carelessly observed by the students. The Chief Examiner's report therefore recommended that mathematics teachers should use inspiring methods of teaching that will reduce students' mass failure in senior secondary schools mathematics examinations.

2.5 Concepts of Factorization, Completing the Square, Formula and Graphical Method

The concepts are used in the solution process of quadratic equations in senior secondary schools. In factorizing the general quadratic equation formula, half coefficient of x is added to both sides of the equation before the equation could be factorized, $x^2 + \frac{bx}{a} + \frac{b2}{a^2} = \frac{-c}{a} + \frac{b^2}{a}$., after they must have divided both sides of the equation by the coefficient of x^2 which is a, equation can then be factorized on the left hand side and be simplified on the right hand side (Pretoria's et al., 2006).

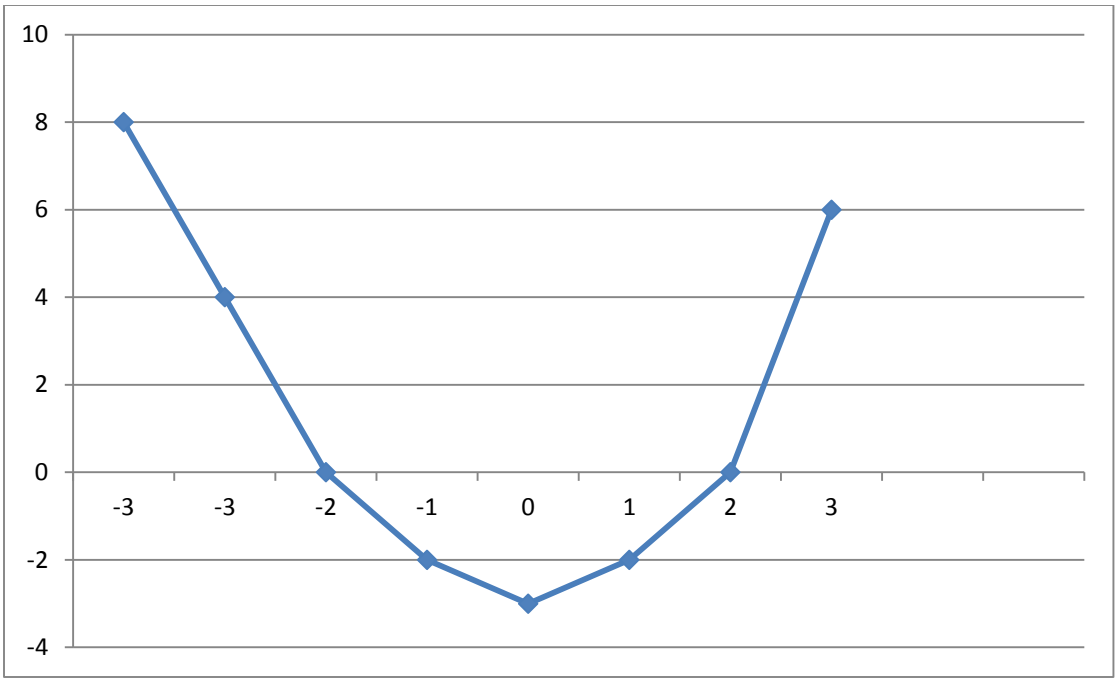
Clarkson (2007) found that comprehension error made up a high proportion of the errors made when students attempt to solve mathematical word problems leading to quadratic equations. Completing a square method in quadratic equations is a method of solving quadratic equations which is helpful if applied appropriately in finding the solutions to the equations. Hence, Students are encouraged to apply the concept accordingly in order to provide correct answers. Graphical method of evaluating quadratic or polynomial equations p(x, y) = 0 is the set of points in the plane the ordered coordinates of which represent the solution set p(x, y) = 0

Egbe, (2005.). Properties of quadratic equations or parabola given the parabola with the equation $y = ax^2 + bx + c$, $a \neq 0$:

(i) if $a > 0$ the graph opens upward

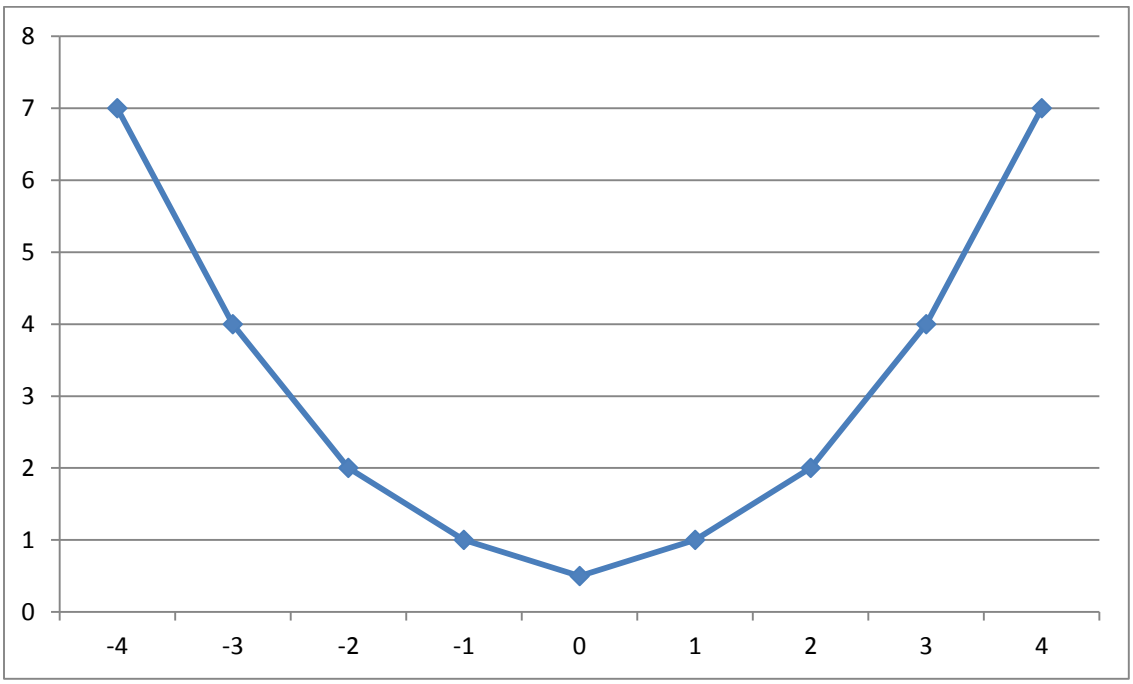
(ii) if $a < 0$, the graph opens downward

(iii) if $ax^2 + bx + c = 0$ has a real solutions or roots x_1 and x_2, where $x_1 \neq x_2$.



(iv) if $ax^2 + bx + c = 0$ has two roots, the graph touches the x-axis at the point $x = x_1 = x_2$. This means that the x-axis is tangent to the graph at $x = x_1 = x_2$.

(v) if $ax^2 + bx + c = 0$ has no real roots, it is said to have imaginary roots, the graph neither crosses nor touches the x-axis.



(vi) the graph is symmetrical about the line x = $\frac{-b}{2a}$

(vii) the vertex of the parabola is the point [$\frac{-b}{2a}, \frac{-b2+4ac}{4a}$]

(viii) two methods of calculating the values of the dependent variable y, given the domains of x are, either by substitution or by the use of tables to calculate the values of y given the corresponding values of x. the graph of a.

(ix) by the gradient b and intercept c. Suppose that instead of $y = ax^2 + bx + c$, we have $ax^2 + bx + c = k$ or $ax^2 + bx + c = mx + k$. Then, instead of intersection with the x-axis (i.e. the line y = 0) the solution we now seek are the x-coordinates of the points of intersection of the graphs of the curve $y = ax^2 + bx + c$ and the line y = mx + k. Egbe (2005).

2.6 Academic Performance of Students in Mathematics

Over the years, the performances of students in mathematics in Nigerian Senior Secondary Schools have been very poor, Amoo (2010), viewed that inappropriate use of teaching methods is the major cause of students' poor performance in tests and examinations. Teaching method include lecture, discovery, expository, laboratory, inquiry, deductive, inductive, inquiry-demonstration among others, though the teaching methods have been found appropriate and effective in the teaching of difficult concepts in mathematics. Annemie and Martin (2011) stated that the term performance is used in parallel to other concepts, such as achievement, outcome, result, output, productivity and many others. Often, there are connotations and denotations linked to these terms.

Performance refers to student's outcomes in mathematics test scores as measured with a specific instrument and neglects the full complexity of the processes involved in resulting to a particular score. However, other factors that affect the students' performance include attitudinal changes of the students toward learning of mathematics, inability to cope with the learning difficulties in mathematics, students' anxiety toward learning and solution process of mathematical problems especially in algebra, lack of motivations by parents, teachers and peer groups, peer groups influenced in the teaching and learning of mathematics among others attributed to the poor performance of students in mathematics (Panel, 2008).

2.7 Mathematics Teaching Methods

There are different types of teaching methods in the teaching and learning of mathematics all geared towards the improvements of teachers and students performance. These teaching methods are classified into traditional otherwise known as conventional methods and experimental methods of teaching and learning. The traditional methods of teaching includes: Expository, lecture and conventional methods of teaching and learning among others (Suleiman, 2010; Usman, 2005 & James, 2008). On the other hand experimental methods of teaching and learning of mathematics includes: Inquiry, deductive, inductive, inquiry-demonstration, problem solving methods of teaching and learning of mathematics among others.

2.7.1 Lecture Method of Teaching

Usman (2005) highlighted some limitations of the method which include among others; lecture method does not promote meaningful learning of mathematics because it appeals to hearing only. The difference in students' ability is not considered because it cannot satisfy the difference in individuals such as slow learners and fast learners; students easily become restless and

disruptive since their attention span is very limited; and it encourages rote learning and regulating of information without necessarily aiding understanding because it does not promote academic performance in mathematics. James (2015) stated that lecture method is cheap; it is not expensive as only chalkboard is required in the teaching process. The method offers very easy coverage of the syllabus and faster dissemination of scientific information, fact and mathematical formulae. The method also allows easy handling of large classes without much stress.

2.7.2 Inquiry-Demonstration Method of Teaching Mathematics

According to (Suchman, in Mujibul, 2008) the originator of an inquiry teaching programme that was widely used throughout the United State once said "inquiry is the way people learn when they're left alone." Inquiry is the natural way human beings learn about their environment. Think for moment about a very young child left in a play yard with objects free to explore. The child, without any coaxing will begin to explore the objects by throwing, touching, pulling, banging them, and trying to take them apart. The child learns about the objects, and how they interact by exploring them, by developing his or her own ideas about them in shot learning by inquiry. The ground of "any belief" occurs through inquiry processes: reason, evidence, inference and generalization (Sola & Ojo, 2013).

2.7.3 Inductive and Deductive Inquiry Method of Teaching Mathematics

Inductive inquiry is an inquiry teaching method that comprises of inquiry-demonstration, sources of inquiry activities and deductive inquiry developed by Suchman (2008:89). It is an inquiry programme designed to help students to find out about the science phenomena through inquiry. Suchman's views on inquiry are quite applicable today, and this statement by him is worth pondering:

> ‘Inquiry is the active pursuit of meaning involving thought processes that change experience knowledge (Suchman, 1998:89 in Mujibul, 2008). When we see a strange object, for example, we may be puzzled about what it is, what it is made of, and what it is used for, how it came into being, and so forth. To find answers to questions (emphasis mine) such as these we might examine the object closely, subject it to certain tests, compare it with other, more familiar objects, or ask people about it, and for a time our searching would be aimed at finding out whether any of these theories made sense. Or we might simply cast about for information that would suggest new theories for us to test. All these activities observing, theories, experimenting, theory testing are of inquiry. The purpose of the activity is to gather enough information to put together theories that will make new experiences less strange and more meaningful’.

The key to the inquiry model is providing “problem-focus events”. Suchman’s program provided such events, but he also advocated demonstrations, and developed a series of idea books for the purpose of helping students organize concepts. It is the inquiry-demonstration that we use to help teachers to develop inquiry lessons. In this approach to inquiry the teacher presents generalizations, principles or concepts, and then engages students in one or more inquiry activities to help understand the concept (Suchman in Mujibul, 2008) defined inquiry-demonstration method as a method of presenting a problem to our students. The demonstration is not designed to illustrate a concept or principle of science it is instead designed to present a discrepancy or problem for the students to explore. An inquiry session is designed to engage the class in an exploration of a problem staged by means of the discrepant event. An inquiry session should begin with the presentation of a problem through a demonstration (the discrepant event). Description of the problem will be posed to the students by the use of prepared materials. These include materials from texts, reference books prepared on quadratic equations. The students will be required to apply different skills in solving problems that affect the four components under consideration in this study. That is factorization, completing the square, quadratic formula and graphical method. The researcher intended to use the method in order to take into consideration all the students during the

inquiry-demonstration session towards improving their performance in the subject matter and mathematics in general. For example, suppose the teacher's lesson plan calls for the introduction to the differences between factorization and completing the square methods in the learning process of quadratic equation, the lesson begins with an explanation of factorization method. Next, the teacher discusses how the coefficient of x^2 can be divided all through, squaring it and adding its square to both sides of the equation in order to obtain the roots of the equation (Sello, 2010). After the development of the major concepts through presentation and questioning, the teacher then engages the students in an inquiry activity in which they explore the concepts of factorization and completing the square.

2.7.4 Problem-Solving Method of Teaching Mathematics

Studies on activity-based method of teaching (i.e. Problem Solving) in relation to students' achievement at secondary school level compared to lecture method is relatively few, therefore there is need to investigate this aspect at secondary school level (Bolaji in Olabisi, 2011). Various research findings in relation to teaching of mathematics, lecture method of teaching is favored; this method seems not to allow meaningful learning, hence leading to student's poor performance in mathematics more especially at senior secondary schools level. Suchman's in Mujibul, (2008), stated that inquiry-demonstration is a method of instruction that helps in improving the performance of students over the lecture method.

2.8 Errors on Gender and Academic Performance of Students in Mathematics

The academic performance of students in mathematics depends on the school location, socio-economic background, the teacher qualifications, learner's attitude, the mode of learning activities and sex of the learner. Many studies have pointed out that male students are academically superior to the female's counterparts in science (Usman, 2005). While another study carried out

by Busari, (2005) revealed that, females are academically superior in mathematics and science. In addition a study carried out by Bolaji and Kajuru (2002) revealed no gender difference in mathematics performance. Also, applying the concept of inquiry-demonstration method and lecture method in relation to Newman error and performance on gender in mathematics among senior secondary students in Kaduna state showed no gender difference.

Newman errors remediation's were through: Inquiry-demonstration method, Formative Assessments, Exit formative assessments test, Remediation plan, Matching remediation to students needs, Technology, Problem solving, Inquiry method, Demonstration method, , Inductive method, Deductive method among others. In formative assessments a teacher uses a regular formative assessment in order to identify learning deficiencies in a mathematics classroom. Learners who lack this understanding are frequently using wrong procedures and this generates systematic pattern of errors in solving problems. Newman error hierarchy model is the model of errors investigation proposed by Newman in (Effandi & Siti, 2014). Another problem is that of mathematical processing that consists of transformation, process skills, and encoding answers. The classification implies that the students have to interpret the meaning of the question before they proceed to mathematical processing to obtain appropriate answer. The outcome of the written students' work in their test will be evaluated according to the type of Newman errors in Newman error hierarchy model. Students who failed the written test will be re-examining using the modified Newman interview procedure. So that if the students were able to get the answer correctly, it implies that the error he/she committed in the written test was as a result of carelessness. If the error is committed again, the students will be taken through all the interview process.

Problem solving in mathematics is a skill that is very complex. Sometimes students know how to answer questions stated, but due to carelessness in computation they failed to arrive at the

answer correctly. It shows that mastery of mathematics among the students is still weak. The weakness may be due to the learning process that focus more on rote learning, involves less group work, interaction and communication that influenced the student's performance (Itanku, 2014). Teachers used different formative assessments including exit quizzes, one-on-one explanation and written explanations.

Error has since been discussed long time ago in the 17th century for instance, Bacon and Pierce in Luneta, (2014) asserted that most of the teachers identify learners' errors but rarely diagnose them. They further stated that when analyzing and diagnosing errors learners displayed, we identify the root cause of those errors and how best they can be corrected in order to benefit both learners and teachers. Error in solving mathematical problem often occurs in writing, or orally. During the process of teaching and learning mathematics, that affects the students' performance. Students are usually faced with many obstacles during the process of solving problems. The mastery of basic mathematical knowledge is essential in concept development. Without clear understanding of basic concepts and skills learned in the early stages, results in the learning process become more difficult at the next stages. Thus learning process in mathematics is categorized as hierarchical learning process. While some reports indicate that female students perform academically better than male students, Usman, (2005) in sciences in which case mathematics is among.

Gender difference in mathematics performance has been a great controversial issue in educational domain, research documents shows great discrepancies among girls and boys performance in school mathematics. Long research history in this area shows the male advantage in mathematics achievement is a universal phenomenon (Jason, 2007) In spite of research evidence for male high performance in mathematics; same research findings do not support the difference

by gender in mathematics performance, i.e. no gender difference on the mathematics ability in senior secondary school level. However, Aliyu (2010) showed that female do not enroll into mathematics as their males counter parts despite the importance of the subject to all sexes. Finding from longitudinal study about gender differences in mathematics showed that there was no difference among boys and girls in mathematics performance. Nussbaum (2011) found that male students achieved significantly higher than female students.

2.9 Overview of Related Studies

Various studies related to inquiry demonstration and lecture methods were conducted previously addressing several issues. For example, Sello (2010) conducted a study on error diagnosis and performance learners made in solving quadratic equation by completing the square method. The study covered five South African junior secondary schools of Limpopo Province in Capricorn district. Pretest, posttest, non-equivalent control group of Quasi-experimental design was used, with one intact class. Sample of 150 with 70 in experimental group taught with inquiry method and 80 in control group taught using lecture method. Descriptive statistics of mean and standard deviation was used to test research questions and independent sample t-test and analysis of variance was used in the analysis, Cronbach $\propto$ value of 0.8, at $p < 0.05$ the findings indicated that students' exposed to inquiry method committed few errors compared to those students exposed to lecture method. Learners who were not given opportunity for discussion on the concepts of completing the square method committed more errors than those who were allowed to have discussions. Some learners were afraid to be mocked at by their peers during the lesson. While some teachers are not committed as they come to class late and not maintaining their work, leads to the errors and poor performance in mathematics. The relationships of the study with this study

were that the same technique of analysis was used but different samples, location and remediating package which makes it different with the present study.

There are other related studies on error analysis carried out by different authorities who were only marginally similar but not precisely the same with this study. Teaching approach used by teachers contributed towards learner' errors and misconceptions they posed in solving quadratic equations by completing the square. Learners were not given an opportunity to discuss the concepts and didn't have enough time to practice their work. Another reason was learners afraid of been mocked at by their peers during the lessons. Learners themselves were not committed to their school work, some had parental role to play at home, and some teachers were not committed as they came to class late and not controlling their work Laridon (2010). Despite the similarities with the present study one aspect of quadratic equation was considered and it failed to consider errors committed in factorization, quadratic formula and graphical method. Their study focused on grade II students, fifteen scripts were sampled out of sixty five from five schools. While in this study one hundred students were considered from two schools sampled out of twelve schools. His study was conducted outside Nigeria, while this study was carried out in Nigeria.

A study carried out by Obeka, (2010), in an effort to find out the effects of inquiry and demonstration method on students' achievement, interest and retention on some environmental education concept in geography senior secondary schools, revealed that inquiry and demonstration methods had significant effect on student's achievement, retention and interest in environmental concept of senior secondary students of geography. Among the two experimental methods, inquiry method appeared to be more efficacious than demonstration method in engendering student's achievement, retention and interest in geography. The findings have educational implication for teachers, tertiary institutions, university and government education ministries and parastatal on the

findings to improve teaching, learning and curriculum in future. Obeka, (2010), further recommended that teachers and researchers should be encouraged through seminars and workshops to employ these instructional techniques in teaching geography and other science education courses. Teachers in the field today lack the necessary competence to use appropriate experimental techniques other than the conventional lecture method.

Effadi and Siti, (2014) analyzed errors committed by students in learning quadratic equations. They considered only thirty form three students from a secondary school in Jambi, Indonesia. Diagnostic test and interview method using Newman modified interview method was used as the instrument of their study that included three components: factorization, completing the squares and quadratic formula method. The Newman errors hierarchy model includes reading, comprehension, transformation, process skill encoding and carelessness. Their data were analyzed using descriptive statistics using percentages to identify which error was committed more than other errors. Their findings revealed that, more errors are committed in transformation and process skill. There was no error found in reading, while those who committed encoding and carelessness were relatively few. Their resolution was that the errors committed by the students were as a result of their weaknesses in mastering topics such as algebra, fractions, negative numbers and algebraic expressions. In their study the sample size was small; the technique of analysis was a descriptive design that presents the result in percentages only, in which case they would have used non-parametric statistics like Man-U-Whitney that deals with more than two variables that is factorization completing the squares and quadratic formula, in order to obtain more accurate result, for example, the convenient statistical tool used in the analysis was Inferential statistics of Independent sample t-test.

From the fore mentioned, their study failed to group the students into experimental and control groups which will be required to find the impacts of the experimental variable on remediating these errors in quadratic equation and enhance among senior secondary school students. In addition the study was conducted in a continent different from this continent i.e. Africa. This study is therefore, intended to contribute to the available knowledge about the impact of inquiry-demonstration method on remediating Newman errors in quadratic equations and enhance performance among senior secondary school students in Kaduna state Nigeria. The present study was conducted using a written test and interview. In most studies on error analysis, the thought processes of the subject are taken into consideration. This is because the students whose scripts will be analyzed went through junior secondary schools thus, will not be difficult to pass through the thought processes. Further more in this study quadratic equation of an algebraic process and its components i.e. factorization, completing the square and quadratic formula was considered.

Hollander (2007) assessed errors on written mathematics task, selected a sample of 96 pupils with 42 exposed to demonstration method and 54 exposed to lecture method. Pretest posttest quasi-experimental control group design was used. ANOVA was used to analyze the errors. The findings were that children exposed to demonstration method committed more errors than those exposed to lecture method of teaching. The relationships with the present study were that both studies used different remediating package, category of pupils, techniques of analysis, and geographical locations from others. Clement and Ellenton (2010) carried out error analysis on the written scripts of pupils only. One intact class of 40 students was exposed to inquiry method to assess their performance and estimate Newman errors. Their finding was that, children exposed to demonstration method committed few errors than those exposed to lecture method.

Joseph (2005) Conducted study on error analysis of mathematics students' examination in some colleges of education in Nigeria. Analysis of covariance (ANCOVA) was used to determine the error and performance of students. Sample size of 100 students with 34 considered as experimental group and 66 considered as control group. The study was quasi-experimental. The experimental group and control groups were exposed to inquiry and conventional teaching method. Using t-test statistical tool for analysis and was tested at $\propto = 0.05$ level of significant. The result revealed that those taught using inquiry method were found to score significantly greater than their traditionally instructed peers. The errors committed by those taught using inquiry method were less than the errors committed by those exposed to conventional method of teaching. The relationship with this study was similar in terms of performance and level of education but different in remediating package, scope and locations.

Watson (2005) in his study on analysis of students' error in the learning process of quadratic equation used a sample of 40 senior secondary students to determine the students' errors based on Newman errors hierarchy model that includes reading, comprehension, transformation, process skill, encoding and carelessness in the learning process of quadratic equation. Two instruments were used; diagnostic test and diagnostic interview. Diagnostic test used includes; factorization, completing the square and quadratic formula. While diagnostic interview was used to identify at which level students' errors occurred in solving quadratic equations. Data were analyzed using descriptive statistics; percentage and frequency. The findings showed that most students' make Newman errors in transformation and process skill. There was no Newman errors found in reading. The number of students' who made encoding error and carelessness were few. The Newman errors committed was due to students' weaknesses in mastering algebra topics such as quadratic equations. The relationship of the previous study was that: similar instruments were used in

Newman error analysis. However, performance and remediating package inquiry-demonstration method used in the present study was not used in their study.

From the literature reviewed, the study concluded that the impact of inquiry-demonstration method on remediating Newman errors in quadratic equation and enhancing performance in algebra among senior secondary school students was not carried out by any other researcher in the same location using the same population. Hence, this study is titled impact of inquiry-demonstration method on remediating Newman errors in quadratic equation and enhancing performance in algebra among senior secondary students in Kaduna State. This study was different based on the previous works on Newman errors and performance, with some degree of confidence the used of inquiry-demonstration method could be one of an effective learning frame work than can significantly minimized errors and improve students' performance in algebra.

2.10 Implications of Literature Reviewed on the Present Study

The literatures reviewed have pointed out some of the researchers who conducted their studies in related areas, such as Sello (2010) who carried out his a study on error diagnosis and performance learners made in solving quadratic equation by completing the square method. The study covered five South African junior secondary schools of Limpopo Province in Capricorn district. In a related, studyHollander (2007) assessed errors on written mathematics task, selected a sample of 96 pupils with 42 exposed to demonstration method and 54 exposed to lecture method. Pretest posttest quasi-experimental control group design was used. ANOVA was used to analyze the errors. The findings were that children exposed to demonstration method committed more

errors than those exposed to lecture method of teaching. Most of the researches were on student's errors, and performance.

The implication of the previous studies on the present study can be seen in the following areas: inability of the researchers to use inquiry-demonstration method as a teaching strategy and Newman errors hierarchy in order to find the errors committed by the students in the solution process of algebra in mathematics; in addition, most of these studies were conducted outside Nigeria. The techniques used for data analysis in the previous studies were not as many as the ones used in this study. The researcher used five techniques that includes percentage, frequencies, ANOVA, Schaffer's test, Chi-square and t-test analysis in which case none of these studies used same. Another implication of this study on the previous studies was that previous studies did not consider areas such as Newman errors, inquiry-demonstration method in learning process of algebra in mathematics as well as their impact on performance among gender at senior secondary level a gap to fill by this study. Similarly, previous studies were geared towards gender imbalance among students due to the type of teaching methods. Hence, this study was conducted to fill the missing gaps in determining impact of inquiry-demonstration method on remediating Newman errors and enhance performance in algebra among senior secondary school students. The reviewed also covered the theoretical basis of the previous studies on the Newman errors committed by students in senior secondary schools. Most of the literatures reviewed are on primary, junior secondary school level 2 errors and academic performances. However, few of the reviewed literature showed that non-activity-based method such as lecture and discovery method do not significantly affect the academic performance of the students in mathematics of senior secondary school level 2, but using inquiry-demonstration method is relatively new. These studies therefore intend to fill this gap. The study then focuses on SS2 students with the view to finding out the

effects of inquiry-demonstration method of teaching on students' errors and academic performance among SS2 students. This became necessary in order to bridge the gaps which related studies have not bridged. No similar study in mathematics at the senior secondary School level 2, that inquiry-demonstration method was used.

Methodologies adopted by different scholars in their researches and limitations associated with such methodologies have been reviewed accordingly. For example, their various research designs and data analysis techniques were not appropriate in producing evidences to support their research data, because most of those researches used survey design. This study is therefore intended to contribute to the available knowledge about the different types of Newman errors committed by students. The model measures both the written errors and errors committed in the thought processes. Moderate samples that were not below the minimum sample size of 30 in line with central limit theory are used. Hence, the study intended to find the impact of inquiry-demonstration method on remediating Newman errors and enhancing performance in algebra.

CHAPTER THREE

3.1 Introduction RESEARCH METHODOLOGY

The aim of this study is to assess the Impact of Inquiry-Demonstration Method on Remediating Newman Errors in Quadratic Equation and enhancing Performance in algebra among Senior Secondary School Students in Kaduna State, Nigeria. In this chapter, the following are the methods used in conducting this study.

3.2 Research Design

The research design used in this study was pretest posttest quasi-experimental design. The researcher seeks to determine the impact of inquiry-demonstration method on remediating Newman errors in quadratic equations and enhancing performance in algebra among senior secondary school students. The study used two groups; Experimental and Control groups. Experimental group (EG) was exposed to Inquiry-Demonstration Method as a treatment (x_1). While, Control group (CG) was taught using lecture method (x_0). The two groups were pretested (0_1) on errors and performance before treatment, to ensure selection of samples that are not significantly different in abilities in terms of performance before treatment. It was then followed by treatment administration. The two groups were taught quadratic equations for a period of six weeks. After the treatment of the two groups, Posttest (0_2) was administered to the groups in order to determine the impact of inquiry-demonstration method on students' errors and performance in quadratic equation.

The design was recommended by Kerlinger, (1973) and Tuckman, (1975) the research design was represented in Figure 3.1



Figure 3.1 Research Design

Source: Adopted from Kerlinger, (1973) and Tuckman, (1975)

Where;

EG = Experimental group

CG = Control group

X_0 = Lecture Method of teaching

X_1 = Inquiry-demonstration method of teaching

O_1 = Pretest

O_2 = Posttest

3.3 Population of the Study

The population of this study covered all public Senior Secondary Schools II (SSII) students in Zaria Education zone of Kaduna State. The available data from the zone as at 2015 revealed that there were three thousand six hundred and nine 3,609 SSII students with 1,953 male and 1,656 female. There are ten (10) Co-educational schools, six boys' schools and four girls' schools totaling twenty senior secondary schools in the zone. The distribution of the population according to schools is represented on Table 3.1

Table 3.1: Population of the Study

S/No	School	Type of school	Number SSII Students		Total
			Male	Female	
1	Alhuda Huda College	Boys	296	-	296
2	Barewa College Zaria	Boys	198	-	198
3	GGSS Dogon Bauchi	Girls	-	205	205
4	GGSS Kofan Gayan	Boys	-	200	200
5	GSS Zaria	Boy	105	-	105
6	GSS Muchia	Coeducation	100	167	267
7	GSS Aminu	Coeducation	130	78	208
8	GSS Magajiya	Coeducation	104	43	147
9	GGSS Fada	Girls	-	249	249
10	GSS Kaura	Coeducation	265	136	401
11	GSS Tudun Jukun	Coeducation	278	128	406
12	GSS Kofan Gayan	Coeducation	124	76	200
13	SIASS Karau Karau	Boys	188	-	188
14	GSS Chindit Barracks	Boys	-	89	89
15	GSS Dakace	Coeducation	45	32	**77**
16	GSS Kugu	Coeducation	36	25	71
17	GSS Tudun Saibu	Coeducation	48	32	80
18	GGSS Chin-Barracks	Girls	-	82	82
19	GSS Likoro	Coeducation	36	25	61
20	GGSS Zaria	Girls	-	89	89
	T0TAL		**1,953**	**1,656**	**3,609**

Source: (Zaria Education Zone, 2015)

3.4 Sample and Sampling Techniques

Sampled schools used for Newman error diagnostic test comprised of five (5) coeducational senior secondary schools. The schools were selected using stratified random samplings from the folded papers containing the names of the schools, to form the study team. The names of the schools were GSS Kaura, GSS Tudun Saibu, GSS Kofar Kuyanbana, GSS Magajiya and GSS Aminu. The five schools were selected based on their status as well as schools location. The selected schools are more than 10% minimum sample size recommended by Wallen (2000). Pretest was administered to the selected schools to determine which of the schools were comparable in their ability levels using analysis of variance (ANOVA) statistical tool at $p \leq 0.05$. After the pretest the result showed that there was significant difference in which Schaffer's test was conducted to determine the schools that were not significantly different. G.S.S Kaura and G.S.S Tudun Jukun showed no significant difference and were picked for the study (See appendix L).

One intact class from each school was used. G.S.S kaura had 50 male and 35 female totaling 85 students while G.S.S Tudun-Jukun had 63 male students and 38 females totaling 101were selected. The total number of sample size was 186 viable for this study which was in line with central limit theory recommendation that a minimum of 30 sample size is viable for the study of this nature and 5% of the population 3,609 with 1% margin of error was used. The sample size was also in line with Karlinger, (1973), Tuchkman (1975) and Franklin and Wallen, (2000). The two schools were later grouped into experimental and control groups using simple random sampling technique involving balloting method one of the schools picked from the two schools was used as the control group while the second was the experimental group. The schools were

G.S.S Kaura as the experimental group and G.S.S Tudun- Jukun as the control group. The detail of the schools and sample selected is shown in Table 3.1

Table 3.2: Sample for the Study

Group	No of Males	No of Females	Total Sample
Experimental	50	35	85
Control	63	38	101
	113	73	186

3.5 Instrumentation

For the purpose of data collection three instruments were used for the study. The instruments were Quadratic Equation Performance Test (QEPT), Quadratic Equation Newman Error Diagnostic Test (QNEDT), and Modified Newman Interactive schedule (MNIS). The instruments were validated by experts in Science Education Department of Amadu Bello University Zaria. The instruments were pretested and Post-tested.

3.5.1 Construction of Newman Error Diagnostic Test (NEDT)

Newman error diagnostic test NEDT was designed and used to identify errors and types of errors students committed in a quadratic equations error diagnostic test requiring response to a given task in writing. However, prior to the design of the instrument the researcher surveyed some areas in which students problems in the solution process of quadratic equations manifested. Findings from the literature of related studies were appropriate in producing more theory assessment of the problems. The assessment was also used and found to be successful. The outcome of the survey indicated that some student's difficulties were reflected on the Newman errors such as reading errors, comprehension errors, transformation errors, process skill errors, encoding errors and carelessness. Based on the outcome of the short survey as highlighted above, Newman error

diagnostic test was designed to diagnose errors that senior secondary school students frequently committed in quadratic equation.

The test comprises of ten (10) theory questions on the concept of quadratic equation comprises of four components which include factorization, completing the squares, quadratic formula and graphical method. The test instruments were designed by the researcher.

3.5.2 Specification of Newman Error Diagnostic and Test Items

Weighting to objectives, content and types of questions were decided based on the initial outcome of the surveys that include a study on sampled written test of 30 pupils of a junior secondary school students in Jambi Indonesia, from a total population of 102 students conducted by Newman and another similar study by Newman in Prakitipong and Nakamura (2014). Where 50 grade 5 students of senior secondary school from a total of 120 pupils in Thailand was carried out using same content and objectives among other literatures. The table of specification of Newman errors diagnostic test and the weighting of objectives and content for the diagnostic test is presented in Tables 3.6 and 3.7

Table 3.3: **Specification of Newman Errors Diagnostic Test of Experimental and Control Groups**

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error	**Per. (%) Frequency**
1	Factorization Method	-	-	-	-	-	-	-	-	-	-
2	Completing the Square Method	-	-	-	-	-	-	-	-	-	-
3	Formula method	-	-	-	-	-	-	-	-	-	-
4	Graphical method	-	-	-	-	-	-	-	-	-	-
5	Total	-	-	-	-	-	-	-	-	-	-

Per. (%)	Error

Table 3.4 Item Specification of Newman Errors Diagnostic Test Items

Content	Know	Comp	App	Anal	Eva	Total	No. of questions	**Per.(%) weight**
Factorization	2	2	2	2	2	08	2	**25**
Completing the Square	2	2	2	2	2	08	2	**25**
Quadratic Formula	2	2	2	2	2	08	2	**25**
Graphical Method	2	2	2	2	2	08	2	**25**
Total	**08**	**08**	**08**	**08**	**08**	**40**	**8**	**100**

Construction of Questions for NEDT

Test items were prepared based on the topics chosen for the study testing knowledge, Application and Skills of subject matter. The test consisted of 08 theory questions as outlined in Table 3.3. Materials from the literatures of the previous researches as indicated above were consulted during the design of NEDT. The sample of the NEDT is attached in appendix C.

Preparation of Marking Scheme for NEDT

In this situation errors committed by the students were carefully identified based on student's response to each question. The errors are categorized based on reading, comprehension, transformation, process skill, encoding and carelessness. See appendix k for the sample results, of three students indicating the different types of errors committed by the students.

Newman Errors Diagnosis/Identification

Newman errors committed by the students are identified accordingly following the steps/guide as follows.

- **Reading Error:** inability of the students to read the questions or items of the instruction clearly or completely so that they can understand the question and reduce the idea into writing. Then reading error is committed.
- **Comprehension Error:** if students cannot understand the terms used in the questions which may be as a result of ignoring the mathematical terminology, ability to read the question but do not know what is required of him among others then the student is said to have committed comprehension errors.
- **Transformation Error:** students who cannot make correct computations, especially among the low achievers and manipulations of signs i.e. addition, subtraction, multiplication and division, inability to interpret the ideas into a good beginning then among other related reasons then, transformation error is committed.
- **Process skill error:** if the students cannot factorize, expand, clear coefficient of quadratic in x, clear the constant to the other side of an equation, take the square roots of both sides of an equation, inability to separate the values of the variable used in the equations, inability to manipulate the operations i.e. addition, subtraction, multiplication and division, when developing algebraic expressions, this error also occurred when replacing values that has a negative sign among others then, process skill errors are committed.

- **Encoding error**: occurred when the student cannot conclude with the right answer, Carelessness occurred when the student forgets to write the correct operation.
- **Carelessness:** if students cannot be able to answer the written test correctly, but was able to answer same question correctly when interviewed using modified Newman interview. Then according to Newman the mistake he made in the written test was as a result of carelessness.

3.5.3 Validity of Newman Errors Diagnostic Test (VNEDT)

The instrument was validated by experts with minimum of Ph.D. qualification and minimum rank of Senior Lecturers in Science Education Department of Ahmadu Bello University Zaria. They assessed the content and face Validity of Newman Errors Diagnostic Test VNEDT. The assessors were requested to examine the instrument to see whether the items

a. Ascertain the reliability of the instrument before use in the final study.
b. To determine whether the study is feasible or not.
c. To ascertain suitable time duration required by the students to complete the test items.
d. To eliminate ambiguity and assess clarity of the items.
e. To determine discrimination level and difficulty of the test items.

Difficulties and problem areas that were observed in the test were carefully noted from the result of pilot test. During validation, questions 2, 5, 7, and 8 was shown to be difficult, because the coefficient of the variables were fractions and was reframed. The corrections were made accordingly and the instrument was employed for the research work.

3.5.4 Quadratic Equation Performance Test (QEPT)

The second instrument consisting of ten (08) theory test items grouped into four sections to determine the performance in quadratic equation. Section A. required students to determine the roots of quadratic equations using factorization method. Section B required students to solve the quadratic equation using completing the square method and section C required students to solve the equations using formula method and section D required students to find the roots of the equation using graphical method. The performance test scores are presented in appendix F and G. Quadratic equation performance test was administered to both the experimental and control groups as pretest to determine the academic performance level of the subject. A marking scheme was designed for marking the sample as follows: Each of the 12 items in the question was assigned five (05) marks each. Total score of 60 marks (Appendix C).

Preparation for the Design of QEPT

Weighting to objectives, content and types of questions were decided based on the initial outcome of the surveys that include a study on sampled written test of 30 pupils of a junior secondary school students in Jambi Indonesia, from a total population of 102 students conducted by Newman in Effandi & Siti, (2014). 50 grade 5 students of senior secondary school form a total of 120 pupils in Thailand were considered for the weighting of objectives and content in diagnostic test presented in Table 3.3

Table 3.5 Item Specification on Performance Test Items

Content	Know	Comp	App	Anal	Eva	Total	No. of questions	**Per.(%) weight**
Factorization	2	2	2	2	2	08	2	**25**
Completing the Square	2	2	2	2	2	08	2	**25**
Quadratic Formula	2	2	2	2	2	08	2	**25**
Graphical Method	2	2	2	2	2	08	2	**25**
Total	**08**	**08**	**08**	**08**	**08**	**40**	**8**	**100**

Test items were prepared based on the topics chosen for the study testing knowledge, Comprehension, Application, Analysis and Skills of subject matter. The test consisted of 08 theory questions as outlined in Table 3.3. Materials from the literatures of the previous researches as indicated above were consulted during the design of QEPT. The sample of the QEPT is attached in appendix C.

Preparation of marking scheme for QEPT

In this situation student's performance were recorded based on gender. See appendix C and Appendix D for the marking scheme and sample results. .

3.5.5 Validity of Quadratic Equation Performance Test VQEPT

The instrument was validated by experts with minimum of Ph.D. qualification and minimum rank of senior lecturers in Science Education Department of Ahmadu Bello University Zaria. They have also assessed the content and face validity of the instrument QEPT. The assessors were requested to examine the instrument to see whether the items have the following qualities.

a. Ascertain the reliability of the instrument before use in the final study.

   To determine whether the study is feasible or not.

c. To ascertain suitable time duration required by the students to complete the test items.

d. To eliminate ambiguity and assess clarity of the items.

e. To determine discrimination level and difficulty of the test items.

Difficulties and problems areas that were observed in the test were carefully noted from the result of pilot test. During validation, question 1, 5, 6, and 8 was shown to be difficult, because coefficients of the questions were big and was reframed. The corrections were made accordingly and the instrument was employed for the research work

3.5.6 Modified Newman Interactive Schedule (MNIS)

The third instrument used was Modified Newman Interview proposed by (Newman in Effandi & Siti, 2014). The model name was adapted to Modified Newman Interactive Schedule maintaining the same five steps process. This was because the interview involved face to face interaction following the schedule executing each in steps to logical conclusions'. The model is a thought process; aimed at finding at the levels of Newman errors committed by the students. It also aimed at identifying the reasons why the errors were committed by the students. The interview was designed for those students who failed the written test. The procedure is represented below.

Can you read the question? (Reading level)

What does the question ask you to do? (Comprehension level)

What do you use to solve the question? (Transformation level)

Can you show the working steps that you have used to find the answer? (Process skill level)

Tell me what is your answer? (Encoding level)

3.5.7 Validity of Modified Newman Interview Schedule (MNIS)

This instrument was adopted by the researcher and was further validated by two experts with minimum of Ph.D. qualification and minimum rank of senior lecturers in Science Education Department of Ahmadu Bello University Zaria. They have also assessed the content and face Validity of Modified Newman Interview VMNI. The assessors examined that the items of the instrument were:

a. Reliable before used in the final study.
b. Found to be feasible.
c. Suitable in terms of time duration required by the students to complete the test items.
d. Not ambiguous and assess clarity of the items.
e. Normal in terms of discriminating and difficulty of the test items.

All problems areas were carefully observed from the result of pilot testing. Having satisfied with the items of the instruments the researcher was permitted to use them for the study.

3.6 Pilot Testing

The Three instruments Quadratic Equation Performance Test (QEDPT), Newman Errors Diagnostic Test (NEDT) and Modified Newman Interview (MNI) were subjected to pilot testing to a group of thirty (30) Students of GSS Aminu Zaria that was not part of the study sample but part of the population in order to prevent students of the sampled schools from having an idea of the instruments. It was administered once to the group after which split half method was used and analyzed using Pearson Product Moment Correlation Coefficient (PPMCC). The three instruments

were administered twice to the same group of students using test re-test method with intervals of two weeks based on Tuckman (1975) recommendation. In order to test the reliability of the instruments, appropriateness of the items of the instruments and ability level of the students. The reliability of the instrument was found to be 0.881 and 0.872. The data generated from the pilot study was used for item analysis.

3.6.1 Reliability of Newman Error Diagnostic Test (RNEDT)

Pearson Product Moment Correlation Coefficient (PPMCC) was used to determine the reliability of the instrument and found to be 0.74 which indicated high correlation between the tests items. The result obtained was shown in (appendix D). Therefore, the instrument was recommended for used.

3.6.2 Reliability of Quadratic Equation Performance Test (QEPT)

Reliability is the consistency of the test items to produce similar result after several times of administration. Test retest method was adopted and Pearson Product Moment Correlation Coefficient (PPMCC) was used to determine the reliability of the instrument and was found to be 0.881 which indicated high correlation between the tests items. The result obtained was shown in (appendix C).

3.6.3 Reliability of Modified Newman Interactive Schedule (RMNIS)

The reliability of the instrument Modified Newman Interview (MNI), was found to be normal. However, the numerical value of the reliability of the instrument was not required because the activities involved in this instrument were mainly thought process.

3.7 Item Analysis

The procedure for item analysis followed.

3.7.1 Facility Index (FI)

The facility indices of the first two test items i.e. Quadratic Equation Performance Test (QEPT) and Newman Errors Diagnostic Test (NED) were calculated to be 0.80 and 0.81 recommended and considered by Satterly (1986), Frust (1958), as adequate for selecting good test items for Performance and Newman Errors test. In this study therefore, the items facility indices of 0.80 and 0.81 was used for this study.

The facility indices otherwise known as difficulty indices were found to be 0.80 and 0.81, the facility indices of the two instruments QEDPT and NEDT was determined using Frust (1958), formula.

$$F = \frac{RU+RL}{N} \; X \; 100$$

Where;

RU = No. of upper 27% of those who got the items correctly.

RL = No. lower 27% who got the items correctly.

N = Total number of students in each of the upper and lower groups (not the total respondents of the test). However, facility index of 0.75 and above were manageable. The ranges of values below were considered difficult and bad.

3.7.2 Discriminating Index (DI)

According to Frust, (1958) and Usman, (2005), items in a test with discriminating indices between 0.30 and 0.49 were considered moderately positive while those with discriminating index of 0.49 are highly positive and if solely used, the well informed students will get the test items right than the poor ones. The discriminating indices for the two instruments were 0.82 and 0.83.The discriminating Indices for the items of the instruments was computed by subtracting the number of students in the lower group who score the item correctly from the number in the upper group who got the item correctly. The number was divided by half the number of the students;

$$D = \frac{RU-RL}{1/2N}$$

D = Discriminating Index

RU = Number among upper 27% who score the item correctly

RL = Number among the lower 27% of students who score the items correctly.

1/2N = Number of students in each of the upper and lower groups.

The results obtained indicated that the calculated values of the discriminating indices of the two instruments that lay between 0.75 and above were manageable. The ranges of values below were considered difficult and 0.25 to 0.75 were considered moderately high and 0.76 and above were considered too simple items and are bad.

3.8 Procedure for Identification of Newman Errors

The aim of Newman error diagnostic test was to identify what the students do not understand in the learning process of quadratic equation. It was a study of learning difficulties. The following represent procedures or steps for identifying six different types of Newman errors that was committed by the students. For the purpose of Newman errors identification and the error types the five coeducational schools that were randomly selected and indicated in table 3.9 were used. 290 randomly selected students out of 467 students from the five (5) selected schools participated in the error diagnostic test. The test comprised of 8 essay type questions with two questions from each of the four components of quadratic equation; factorization, completing the square, quadratic formula and graphical methods. The test items were administered by the researcher with the assistance of subject teachers in the various schools used. However, no time limit was set for the diagnostic test. It was because the test was not for speed but for Newman errors identifications. However, 2 hours was allocated for the test with 15minutes per question. The scripts were marked according to marking scheme. Each of the 8 items was scored 12 ½ marks totaling 100 marks. Newman errors committed by the students in each item were identified based on the given task for each questions. Examples were the students were asked to read the questions and they were not able to do it. The students committed reading errors. The frequencies of Newman errors identified from the four components and their summaries were calculated and recorded based on gender in Table 4.01. The results included the summaries of the errors committed by the students after the pretest and posttest. The posttest results were obtained using a remediating package adapted Suchmans' inquiry-demonstration method. The procedure on how Newman errors are committed was presented below.

- **Reading Error:** if students cannot read the questions or items of the instruction clearly or even completely so that they can understand the question and reduced the idea into writing reading error is committed (Newman, 1977 in Effandi & Siti, 2014).
- **Comprehension Error:** if students cannot understand the terms used in the questions which may be as a result of ignoring the mathematical terminology, ability to read the question but do not know what is required of him among others then the student is said to have committed comprehension error. Process skill error occurred when the student cannot reduce the concept into the right procedure to a logical conclusion. Encoding error occurred when the student cannot conclude with the right answer, Carelessness occurred when the student forget to write the correct operation
- **Transformation Error:** students who cannot make correct computations, especially among the low achievers and manipulations of signs i.e. addition, subtraction, multiplication and division, inability to interpret the ideas into a good beginning then among other related reasons then, transformation error is committed.
- **Process skill error:** if the students cannot factorize, expand, clear coefficient of quadratic in x, clear the constant to the other side of an equation, take the square roots of both sides of an equation, inability to separate the values of the variable used in the equations, inability to manipulate the operations i.e. addition, subtraction, multiplication and division, when developing algebraic expressions, this error also occurred when replacing values that has a negative sign among others then, process skill errors are committed.
- **Encoding error:** if students cannot write the correct answers to the questions then they have committed encoding.
- **Carelessness:** if students cannot answer the written test correctly, but was able to answer same question correctly when interviewed using modified Newman interview. Then

according to Newman the mistake he/she committed in the written test was as a result of carelessness.

Table 3.6: **Co-educational Schools Selected for Newman Error Diagnostic Test**

SN	School	Students in School	Male in Class	Female in Class	Total Students in Class	Selected Male Students	Selected Female Student	Total Sampled Schools
1	GSS Kaura	401	73	35	108	50	35	85
2	GSS T/Jukun	406	89	58	147	63	38	101
3	GSS Kofar K/B	200	34	28	62	20	14	34
4	GSS Magajiya	147	42	30	72	20	15	35
5	GSS Aminu	208	45	33	78	20	15	35
	Total	1362	283	184	467	173	117	290

3.8.1 Remediating Package (Inquiry-Demonstration Method)

From the identified Newman errors and their types, a remediating package, Suchman's inquiry-demonstration method was adapted. The remediating package was found to be effective for remediation of problem solving difficulties in quadratic equations by completing the square method, carried out in five South African junior secondary schools of Limpopo province in Capricorn district by Sello (2006). Effandi and Siti (2014) also found the remediating package effective in minimizing Newman errors committed by junior secondary students in quadratic equations, in Jambi, Indonesia. Suchman's inquiry-demonstration remediating package is an instructional material that contains hands-on and minds-on activities featured prominently in the lesson plans of the remediating package so as to make the learner actively involved in constructivist knowledge to be learnt and was used to prepared lesson plans of the remediating package in agreement with constructivist view of knowledge as was proposed by (Piaget in Falalu, 2015). Learning theory emphasizing the importance of learners' prior knowledge on learning helped in preparing the package (Ausubel's, in Falalu, 2015). Inquiry-demonstration method was used as instructional method addressing the identified errors. The remediating package Suchman's inquiry-demonstration was presented in figure 2. It was prepared to address and correct the identified Newman errors. It also contains textual materials, reference books so that the students can explore. The contents of the remediating package were obtained from the text 'Models of Teaching' and from the internet. The package was arranged into six steps used in addressing the identified problems. The procedure includes; Questioning, freedom to ask question, testing theories, and teacher respond to statement of theory, cooperation, experimenting and evaluation.

However, Suchman's model does not provide room for introduction and evaluation at the beginning and after the activities. As such the researcher deemed it necessary to integrate them.

This is because for any meaningful classroom teaching and learning situation to take place, introduction and evaluations must be effected. This was in line with the study Bawa and Guga (2014) that evaluating student's performance helped the teacher to know the extent to which his or her instructional objectives have been achieved. Evaluating instructions will help the teacher to know the level of his teaching strategies. The efficiency of the package was being a measure of how the student's performance improved relative to their performance in diagnostic test. The materials in the remediating package were validated by senior lecturers from science education department of Ahmadu Bello University Zaria, Nigeria. The presentation was in hierarchical order of simplicity in line with Gagne's in Falalu (2015). He viewed that concepts and skills to be learnt are to be arranged in hierarchical order, from simple to complex and from known to unknown.

3.8.2 Implication of Remediating Package (Inquiry-demonstration method)

In an effort to implement the remediating instructional package on the experimental group a remediation flow chart adapted from Suchman's was used. The model was adapted by integrating introduction and evaluation this was because for every meaningfully teaching and learning situation to take place, there must be an introduction as a background, students Newman errors and performance then, evaluated at the end of the lesson. According to this model, students learned that in order to obtain information they must ask questions. Questioning become it is the initial method of gathering data. Thus, the climate of the inquiry classroom must poster the axiom "There are no dumb questions". Students were made to believe that teacher will accept their questions no hold barrier. Students in the experimental group comprised of 50 male and 35 female totaling 85 students from G.S.S. Kaura in Zaria city as presented in Table 3.2. The participating students were selected using stratified random sampling technique while the schools were selected using simple random sampling technique involving balloting method.

Students were separated purposely for this activity. At the introduction the researcher presented all the modalities including the benefit that will be derived from the exercise. They were pleased to be punctual as the exercise will last for six weeks. The topic was introduced based on the lesson plan by presenting the concepts of quadratic equation and the components or the different methods of the solution process, that includes; factorization, completing the square, quadratic formula and graphical methods. Each component took the researcher one and half weeks to cover, based on the activities involved in each case. Hands-on and minds-on activities were provided in the lesson to enrich the lesson and enhance remediation of identified Newman errors. During the process of remediation, the researcher used the adapted Suchman's inquiry-demonstration model which is the method of presenting problem through demonstration. The following steps represent Suchman inquiry-demonstration model of teaching as follows;

Rule A: Introduction.

Procedure A: The researcher introduces the concept of quadratic equation and the components i.e. factorization, completing the squares, quadratic formula and graphical method and how the remedial session took place following the lesson plan. The researcher started with Factorization method. The researcher explained different method of generating the factors. However, students were allowed to make their input as a preliminary session.

Rule 1: Questions.

Procedure 1: The researcher haven taught the concept of factorization indicating various alternatives of producing factors; students were allowed to ask question. Students dominate the

discussions been an activity based method of teaching and learning. The questions framed by the researcher were phrased in such a way that they can be answered "yes or no". The burden of thinking was left to the students. This was to allow the students to think towards the correct answer.

Rule 2: Freedom to ask questions.

Procedure 2: Students were allowed to ask as many questions as they required. That encouraged the students to use their previous questions and formulated new ones. The theories were later used to pursue a reasonable theory i.e. correct factors and procedure to correct answers.

Rule 3: **Teacher response to statement of theory.**

Procedure 3: When students suggest a theory or various alternative factors, the researcher refrained from evaluating them, rather the theories were written on the board or the researcher asked them some questions about their formulated theories.

Rule 4: Testing Theories.

Procedure 4: The researcher allowed the students to test their formulated theories or alternative factors at any time within the remediating period.

Rule 5: Cooperation.

Procedure 5: The researcher encouraged them to feel free during the period and encouraged them to work in team in order to confer and discuss their theories i.e. the students put heads together and discussed each other's theories and agreed on the correct factors or theories.

Rule 6: Experimenting.

Procedure 6: The researcher provided the students with the materials, texts, reference books and the students were able to use the materials in form of exercise and explore their ideas on the various factors or theories and solved problems using them.

Rule H: Evaluation

Procedure H: The researcher assessed the students' performance in their efforts to produce the correct factors and used them to solve the problems from the text and other reference materials or theories and identified their areas of strength and weaknesses. The Newman errors committed by the students along sides their performances were identified and recorded accordingly. This was done by the researcher at the end of the lessons using the remediating package.

After the experimental group was treated with remediating package the posttest, comprising the Newman errors diagnostic test and performance test items were administered for the second time in order to determine whether or not the remediating package NEDT and QEPT was effective in remediating the error and improving students' performance in quadratic equation. To find out whether exposure to the remediating package had effect or not on students' performance, the scripts were marked, errors and performances were recorded as was done during pretest. The scores were recorded experimental group separately from control group for the male and female students in order to test for gender difference. However, the theoretical framework of the remediating package based on Suchman inquiry-demonstration model and the adapted Suchmans inquiry-demonstration model were presented in Figure 3.2 and 3.3.

Flow Chart of Suchman's Inquiry-Demonstration Model

The question by the student should be phrased in a way that they can be answered Yes or No. This shifts the burden of thinking on to the student

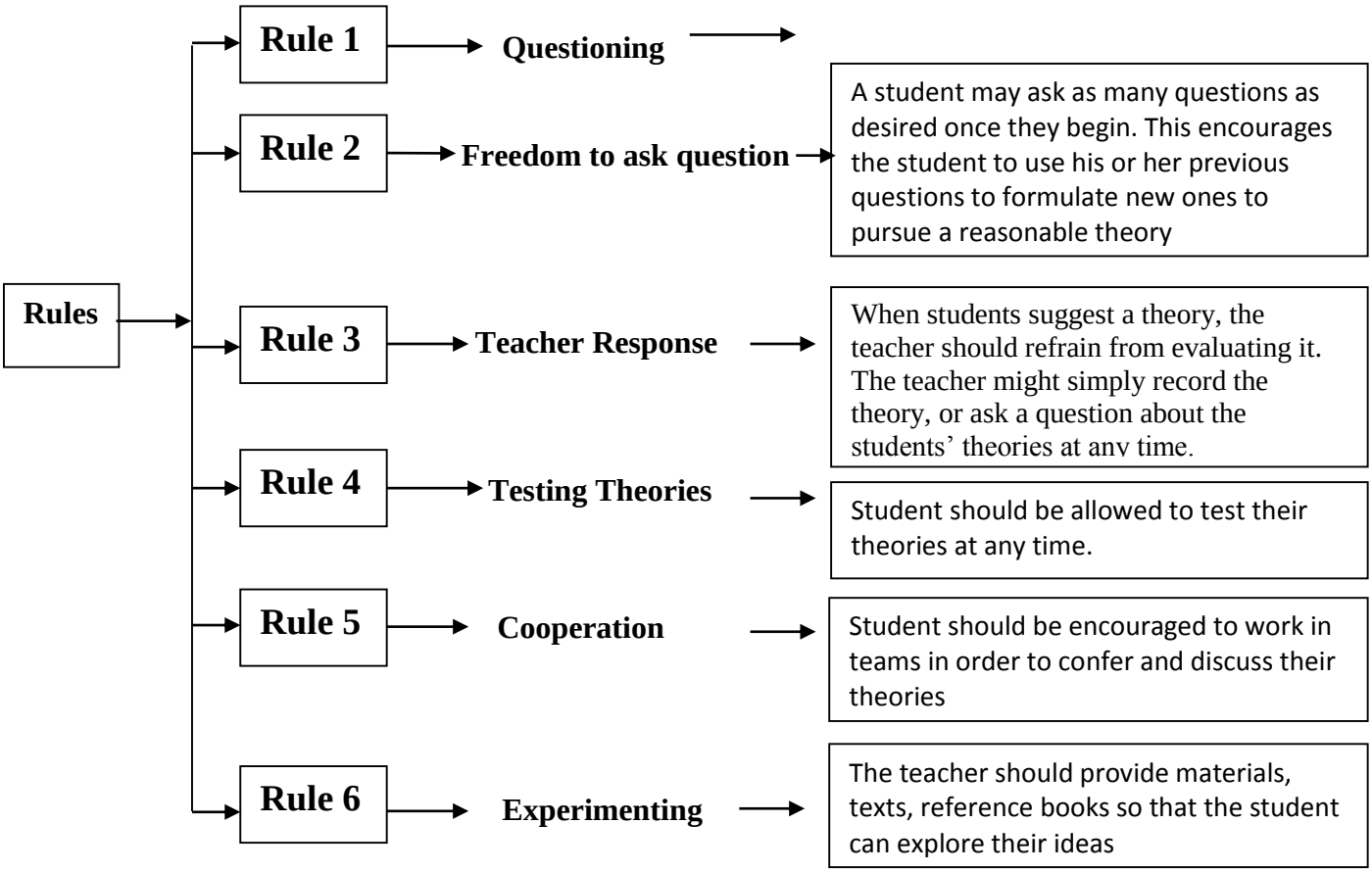
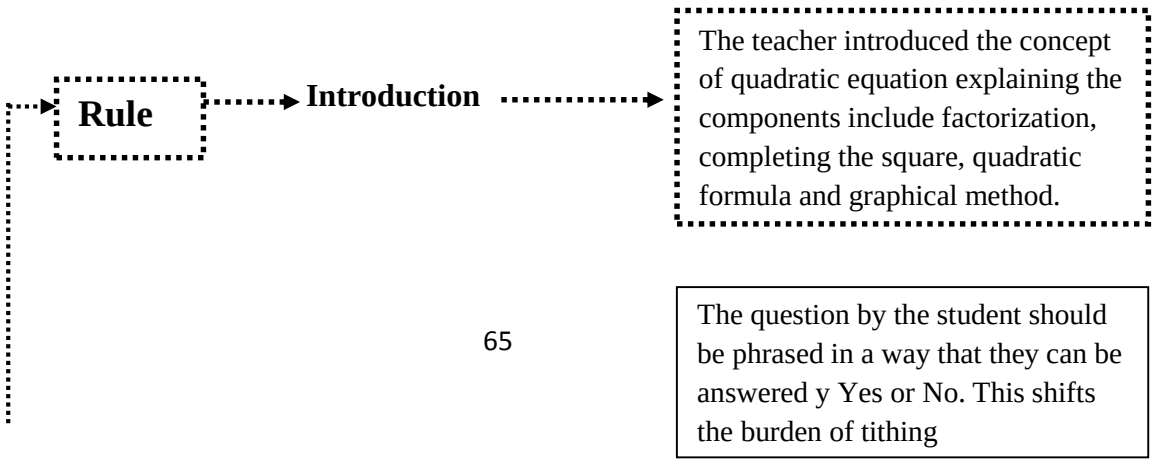


Fig. 3.2 Flow chart for Inquiry-demonstration Model

(Source: Models of Teaching and Learning of Mathematics, 2008)

Flow Chart of Adapted Suchman's Inquiry-Demonstration Model



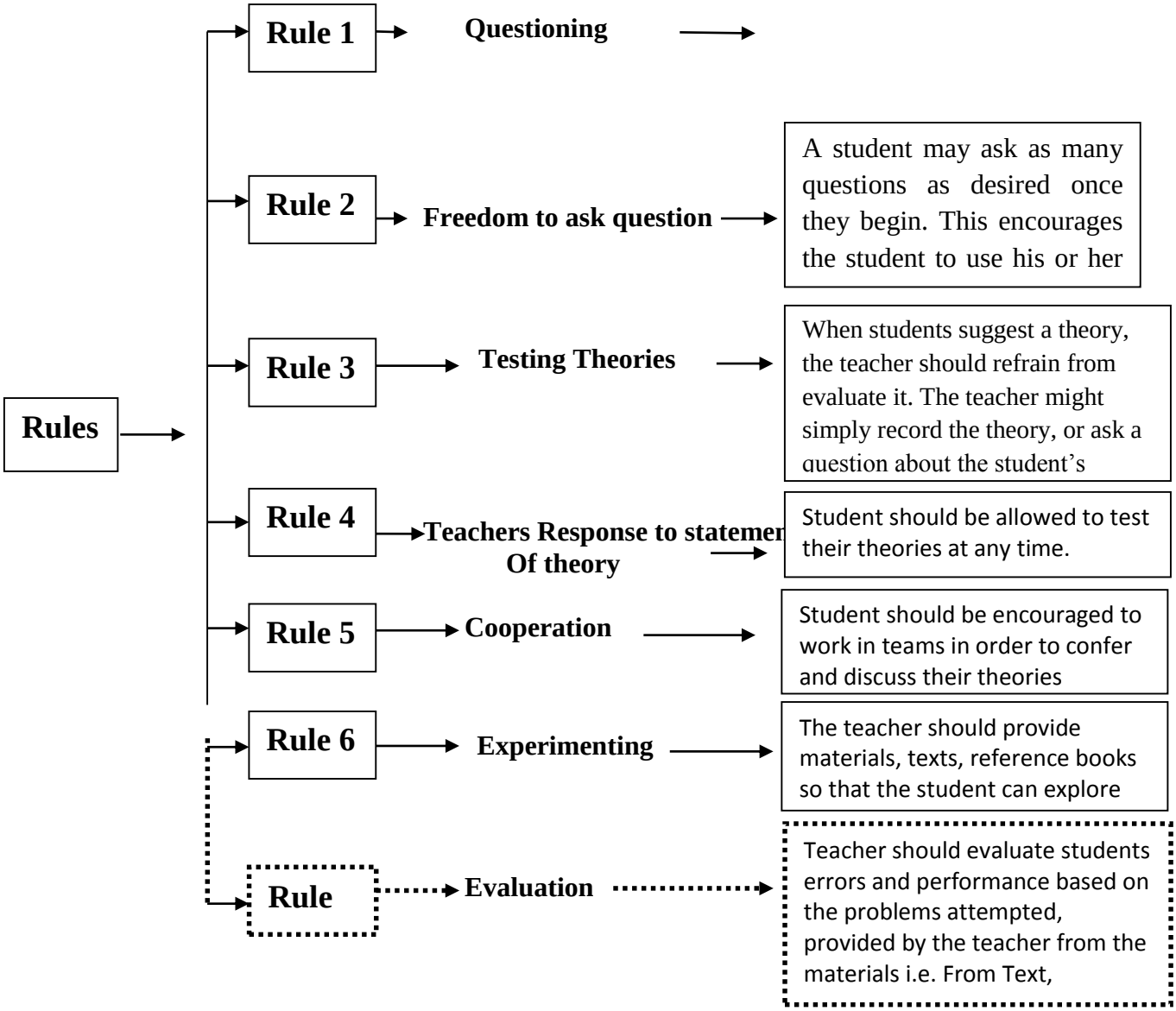


Fig. 3.3 Adapted Flow Chart of a Remediating Package

(Source: Model of Teaching and Learning of Mathematics, 2008)

3.8.3 Manual for Modified Newman Interactive Schedule MMNIS

The manual was designed by Newman for those students who failed the written test. It is a thought process that was used to find out at which level students' errors occurred and

discovered the reasons why the errors are made by the students. It was designed in form of questions as follows.

- Can you read the question? If the student was able to read the question correctly but failed the written test then the previous mistake was as a result of carelessness, or reading error is committed.
- What does the question asked you to do? If the student was able to explain what was required of him, then his failure in the written test was as a result of carelessness, or comprehension error is committed.
- What do you used to solve the question? If the student answered the question correctly then his failure in the written was as result of carelessness, or transformation error is committed.
- Can you show the working steps that you have used to find the answer? If he presented the working steps correctly then his failure in the written test was as a result of carelessness, or he has committed process skill error.
- Tell me what is your answer? If his answer is correct then his previous failure in the written test was as a result of carelessness**.**

3.9 Administration of Treatment

After validating the instruments and lesson plans, the researcher administered the instruments without involvement of research assistance. Suchmans' Inquiry-demonstration method of teaching

was adapted in teaching the experimental group and lecture method of teaching was used to teach the control group.

3.9.1 Teaching of Experimental Group

Government Secondary School Kaura located in Zaria city, with the total number of 401 SS11 students was selected as an experimental group. Government Secondary School Zaria was used for pilot study where 30 students were involved. One intact class of 85 students was considered as the experimental group and 101 tudents for the control group. Experimental group were taught using Suchman's inquiry-demonstration model of instruction and control group were taught using lecture method, for six weeks. The reason for selecting the model was as a result of poor performance of the students as observed by Opadeyi (2006). There were two lessons of one hour twenty minutes each week. Students are allowed to discuss problems in quadratic equations, using factorization, completing the square and formula method during the six weeks. The teacher prompts each student to reflect on and examine his or her current knowledge. When a student comes up with the relevant concept, the teacher seizes upon it and indicates to the group that this might be a fruitful avenue for them to explore. This helps to better understand the concept, and the process led to active construction of meaningful learning rather than passive acquisition of facts transmitted from the teacher. The lesson notes for both the experimental and control groups are presented in Appendix (A) and (B). In conducting inquiry-demonstration sessions Suchman, (2008) proposed six steps models that teacher would found helpful, the major portion of the inquiry session is devoted to the students asking questions to gather data, which is then used formulate to one or more theories. The following steps are taken in executing the model of teaching the experimental group.

Rule A: Introduction.

Procedure A: The researcher introduces the concept of quadratic equation and the components i.e. factorization, completing the squares, quadratic formula and graphical method and how the remedial session took place following the lesson plan. The researcher started with Factorization method. The researcher explained different methods of generating the factors. However, students were allowed to make their input as a preliminary session.

Rule 1: Questions.

Procedure 1: The researcher taught the concept of factorization indicating various alternatives of producing factors; students were allowed to ask questions. Students dominated the discussions it was an activity based method of teaching and learning. The questions framed by the researcher were phrased in such a way that they can be answered "yes or no". The burden of thinking was left to the students. This was to allow the students to think towards the correct answer.

Rule 2: Freedom to ask questions.

Procedure 2: Students were allowed to ask as many questions as desired as soon as they stated. That encouraged the students to use their previous questions and formulated new ones. The theories were later used to pursue a reasonable theory i.e. correct factors and procedure to correct answers.

Rule 3: **Teacher response to statement of theory.**

Procedure 3: When students suggest a theory or various alternative factors, the researcher refrained from evaluating them, rather the theories were written on the board or the researcher asked them some questions about their formulated theories.

Rule 4: Testing Theories.

Procedure 4: The researcher allowed the students to test their formulated theories or alternative factors at any time within the remediating period.

Rule 5: Cooperation.

Procedure 5: the researcher encouraged them to feel free during the period and encouraged them to work in team in order to confer and discuss their theories i.e. the students put heads together and discussed each other's theories and agreed on the correct factors or theories.

Rule 6: Experimenting.

Procedure 6: The researcher provided the students with the materials, texts, reference books and the students were able to use the materials in form of exercise and explored their ideas on the various factors or theories and solved problems using them.

Rule H: Evaluation

Procedure H: The researcher assessed the student's performance in their efforts to produce the correct factors and used them to solve the problems from the text and other reference materials or theories and identified their areas of strength and weaknesses. The students were scored according to their solved problems. In addition, other forms of evaluations were done by the researcher like exit formative evaluation. This was done at the end of the lessons on the remediating package implementations' by the researcher.

After the experimental group was treated with remediating package the posttest, comprising the Newman errors diagnostic test and performance test items were administered for the second time in order to determine whether or not the remediating package NEDT and QEPT was effective

in remediating the error and improving student's performance in quadratic equation. Also the items were administered to find out whether exposure to the remediating package had effect or not on students' performance. After administration of the two tests, the scripts were marked for errors and performances were recorded as was done during pretest. The scores were recorded for experimental group separately from control group as well as for male and female in order to test for gender difference. However, the theoretical framework of the remediating package based on Suchman inquiry-demonstration model and the adapted Suchmans inquiry-demonstration model were presented in Figure 3.2 and 3.3.

Flow Chart of Suchman Inquiry-Demonstration Model

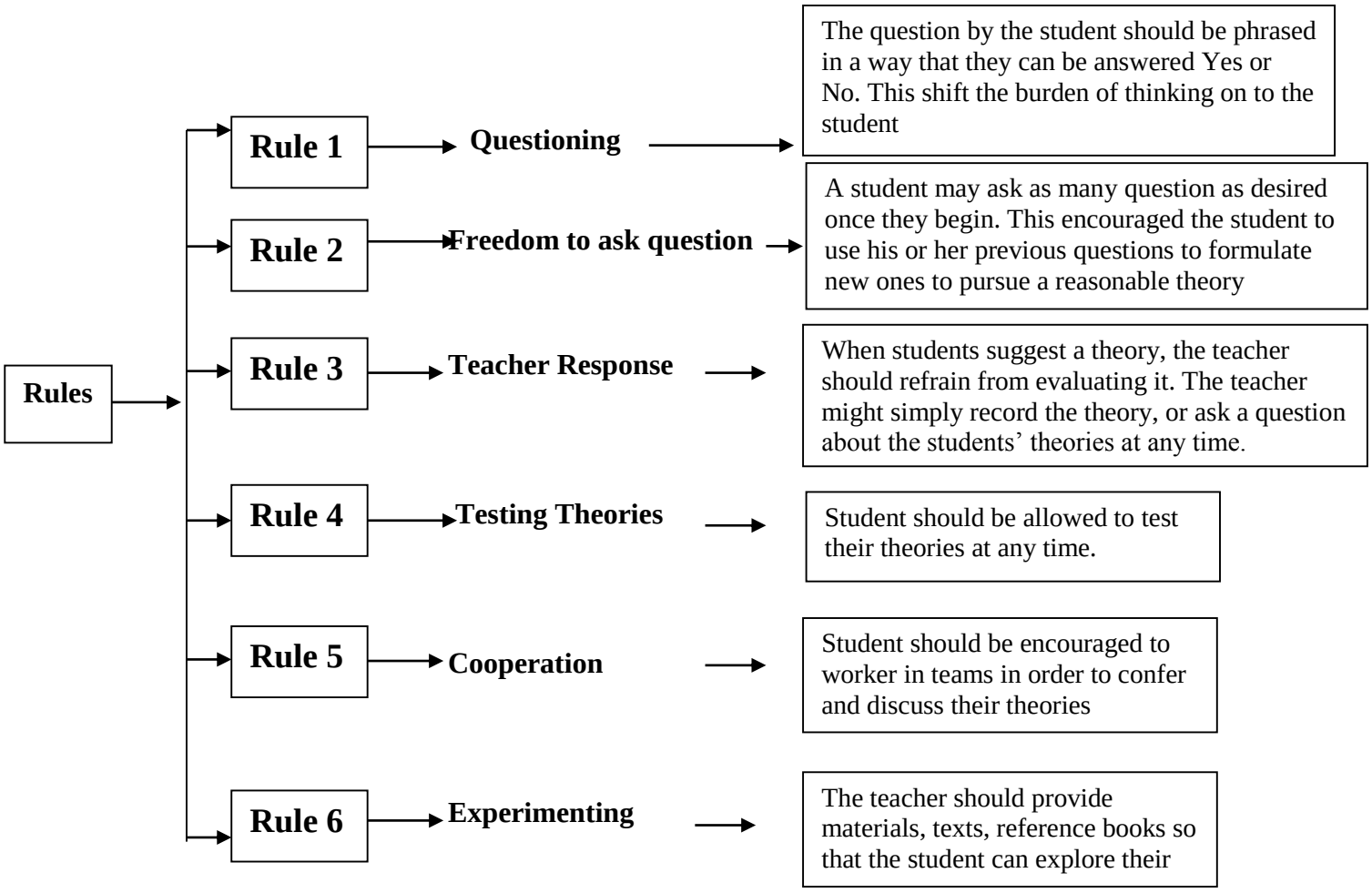


Fig. 3.2 Flow chart for Inquiry-demonstration Model

(Source: Models of Teaching and Learning of Mathematics, 2008)

Flow Chart of Adapted Suchman Inquiry-Demonstration Model

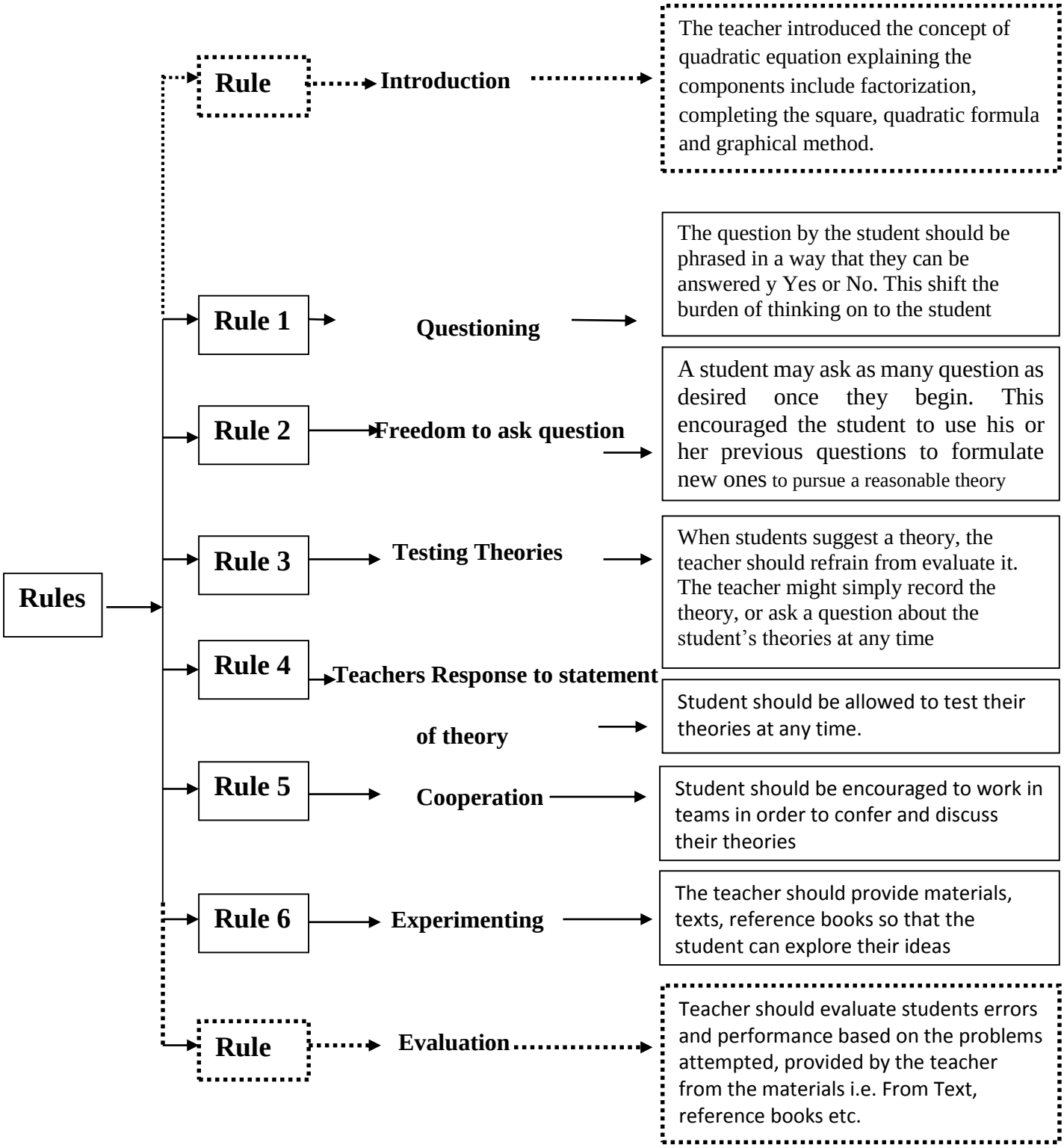


Fig. 3.3 Adapted Suchman Inquiry-Demonstration Model (Remediating Package)

(Source: Models of Teaching and Learning of Mathematics, 2008)

3.9.2 Teaching of the Control Group.

Government Secondary School Tudun Jukun Zaria was considered as control group. There are 406 students' in SS11. One intact class comprising of 101 students was selected using simple random sampling technique as the control group. The students were taught the same topic for six weeks by the researcher using lecture method, which involved verbal presentation of the concept under algebra in mathematics. The detail of lesson note was presented in Appendix (B) Students were allowed to listen for the teaching and wrote down what was being taught and allowed to ask questions were necessary but without engaging into any problem or activity for a period of six weeks. Test items were marked for errors and performances were recorded accordingly. Data were analyzed based on the hypotheses.

3.10 Data Collection Procedure

The researcher conducted the tests, marked and recorded accordingly. The performance and Newman errors were recorded. The pretest was administered on the two groups (experimental and control groups) after the two groups were taught the same quadratic equations using three different methods, it was re-administered for posttest, Factorization, completing the squares and formula method, While the experimental group was exposed to inquiry-demonstration method of instruction, control group was taught using lecture method. For a period of six weeks, the posttest was letter administered to the groups by the researcher using the same items of the instruction. The performance and errors from the scripts were collected and subjected to analysis using a statistical package (SPSS).

3.11 Procedure for Data Analysis

The analyses of data collected, the research questions and null hypotheses raised in chapter one were restated and suitable statistical tools for their analyses are presented as follows;

Null Hypotheses

The following null hypotheses were tested at $P \leq 0.05$ level of significance. Each of the hypotheses was tested along with the description of the statistical tool used for testing.

H_{O1}: There is no significant difference between the frequencies of Newman Errors Committed by the Students in quadratic equations. The nature of data collected for testing the above hypothesis was in frequency form.

Hypothesis one (H_{01}) was used to test for significant difference, Chi-square test statistics was used to test the hypothesis one (H_{01}), at $p \leq 0.05$ level of significance.

H_{O2}: There is no significant difference between the frequencies of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method. The nature of data collected for testing the above hypothesis was in frequency form.

Hypothesis two (H_{02}) was used to test for significant difference. Chi-square test statistics was used in analyzing the data for testing Hypothesis two (H_{02}), at $p \leq 0.05$ level of significance.

H_{O3}: There is no significant difference between the frequencies of Newman errors committed by male and female students in quadratic equations exposed to inquiry-demonstration method.

Hypothesis three (H_{03}) was used to test for significant difference. Chi-square test statistics was used in analyzing the data for testing Hypothesis three (H_{03}), at $p \leq 0.05$ level of significance.

H_{O4}: There is no significant difference in the performance of students exposed to inquiry-demonstration strategy and those exposed to lecture method.

The technique used to analyzed the Hypothesis four (H_{04}) was t-test statistical tool and tested hypothesis four (H_{04}), at $p \leq 0.05$ level of significance.

CHAPTER FOUR

4.1 INTRODUCTION DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

This study assessed the impact of inquiry-demonstration method on remediating Newman errors and enhancing performance in algebra among senior secondary school students Kaduna state, Nigeria. For the purpose of data collection for the survey part of the study, Newman errors diagnostic test was used to identify the types of errors committed by senior secondary school students in quadratic equation. Frequency and percentages were used in answering research questions while Chi-square and t-test statistics were used in testing hypotheses. Data were analyzed using (SPSS) Software version 17.1 and tested at alpha $\propto \geq 0.05$, which formed the basis for retaining or rejecting each of the null hypotheses stated. The decision of findings was also made. This chapter therefore presented the result, interpretation and discussions of findings under the following subheadings:

4.2 Data Presentation Analysis and Discussions

The results of Newman Errors Diagnostic Test (NEDT) and quadratic equations performance test was analyzed and used to answer the research questions.

4.2.1 Results of Newman Errors Diagnostic Test (NEDT)

The results of NEDT was analyzed and used to answer the research questions raised

Table 4.01: **Result of Newman Errors Diagnostic Test (NEDT) Experimental Group (Pretest)**

S/N	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error	**Per. (%)Freq.**
1	Factorization Method	04	06	10	11	07	04	14	28	42	**25.5**
2	Completing the Square Method	06	07	11	12	08	04	16	32	48	**29.1**
3	Formula method	05	06	10	09	05	06	14	27	41	**24.8**
4	Graphical method	04	05	09	10	03	03	11	23	34	**20.6**
5	Total	19	24	40	42	23	17	66	99	165	**100**
	Per. (%)	**8.8**	**11.5**	**28.6**	**31.1**	**12.1**	**8.0**	**28.4**	**39.6**	**100**	

From Table 4.0.4, the results of Newman errors diagnostic test of experimental group pretest showed that the highest Newman errors occurred in process skill errors with 42(31.1%) and transformation errors with 40(28.6%) but fewer errors were committed carelessness with 17(8.0%) and on reading with 19(8.8%) respectively. While the highest errors in respect of the skill applied occurred in completing the square method with 48(29.1) followed by factorization method with 42(25.5%).

Table 4.02: Result of Newman Errors Diagnostic Test NEDT for Experimental Group (Posttest)

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error	**Per. (%)**
1	Factorization Method	03	04	07	07	05	03	10	19	29	**26.4**
2	Completing the Square Method	04	04	07	08	05	02	10	20	30	**27.3**
3	Formula method	04	04	07	06	03	04	09	19	28	**25.5**
4	Graphical method	03	03	06	07	02	02	08	15	23	**20.9**
5	Total	14	15	27	28	15	11	37	73	110	**100**
6	**Per. (%)**	**12.7**	**13.6**	**24.5**	**25.5**	**13.6**	**10.1**	**49.3**	**50.7**	**100**	

From Table 4.02 the results of experimental group posttest indicated that the highest Newman errors occurred was in process skill and transformation errors with total of 28 and 27 correspond to 25.5% and 24.5% while fewer errors were committed in carelessness and reading with total errors of 11 and 14 corresponding to 10.1% and 12.7%. Highest errors occurred in completing the square method with 30 total errors corresponding to 29.1% followed by factorization methods total errors of 29 corresponding to 26.5%.

Table 4.03: Result of Newman Errors Diagnostic Test NEDT for Control Group (Pretest)

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error	**Per. (%)Freq.**
1	Factorization Method	07	10	18	18	12	07	24	48	72	**25.9**
2	Completing the Square Method	10	11	18	20	13	06	26	52	78	**28.1**
3	Formula method	09	09	17	17	08	11	24	47	71	**25.5**
4	Graphical method	06	09	15	17	05	05	19	38	57	**20.5**

5	Total	32	39	68	72	38	29	123	155	278	**100**
	Per. (%)Err	**11.5**	**14.0**	**24.5**	**25.9**	**13.7**	**10.4**	**44.2**	**55.8**	**100**	

From Table 4.03 the results showed that highest Newman errors occurred in pretest control group pretest highest Newman errors in process skill and transformation errors with 72 and 54 errors corresponding to 25.9% and 24.5%. The least errors were committed in reading and carelessness with 11.5% and 10.4% respectively. The highest errors occurred skills was on completing the square method and formula method with 78 and 71 errors which correspond to 28.1% and 25.8%.

Table 4.04: Results of Newman Errors Diagnostic Test NEDT Control Group (Posttest)

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error	**Per.(%) Freq.**
1	Factorization Method	06	08	14	14	09	05	20	36	56	**25.3**
2	Completing the Square Method	08	09	14	16	10	05	21	41	62	**28.1**
3	Formula method	07	07	14	13	07	09	19	38	57	**25.8**
4	Graphical method	05	07	12	14	04	04	15	31	46	**20.8**
5	Total	26	31	54	57	30	23	73	146	221	**100**
	Per Err.(%)	**4.1**	**15.7**	**26.9**	**31.63**	**13.3**	**8.4**	**49.2**	**50.8**	**100**	

From Table 4.01the results of Newman errors diagnostic test of experimental grouppretest showed that the highest Newman errors occurred in process skill and transformation errors with 57 and 54 which correspond to 31.63% and with 26.9%. While the highest errors that occurred was in respect of skills was on completing the square method with 62 and 57 which correspond to 28.1% and 25.8% respectively.

4.2.2 Answering the Research Questions

The survey test was conducted in order to find answers to the research questions and descriptive statistics using frequency and percentages were used in order to answers research questions and inferential statistics u sings Chi-square and t-test statistics were used to test the null hypotheses.

Research Question 1: What is the frequency of the types of Newman errors committed by the students in quadratic equation among senior secondary schools?

From the results of the Newman errors diagnostic test administered to the students, the following errors were identified and presented in Table 4.05

Table 4.05 Identified Newman Errors

S/N	IDENTIFIED NEWMAN ERRORS	Freq.	Per. (%)
1	Inability to read questions given in quadratic equations	19	2.5
2	Wrong determination of the product of quadratic and constant part of the equations, used to find the alternative factors for expansion	24	3.1
3	Lack of understanding the correct factors that will substitute the middle numbers of a given quadratic equations	40	5.2
4	Wrong transformation of correct identities of the factors in the equations i.e. wrong substitutions of operations (+ve) and (-ve) signs.	42	5.4
5	Missing steps in the process of solving problems from beginning to logical conclusions.	23	3.0
6	Problems of transforming correct answers from the wrought work to the end of their work.	17	2.2
7	Inability to separate constants from one side to the other side of the equations in an effort use completing the square method	14	1.8
8	Inability of clearing the coefficients of quadratic part of the equation by dividing both sides by the coefficients.	15	1.9

9	Wrong determination of new coefficients whose square to be added on both sides of the equations, in order to factorize the expressions.	27	3.5
10	Inability to recognize which sides of the equation the square root sign will be placed.	28	3.6
11	Wrong transformation of the operation $\pm$ for the alternative solutions.	15	1.9
12	Inability to recognized the correct general formula to apply involving coefficients of a, b and c. i.e. x = $\frac{-b\pm\sqrt{b^2-4ac}}{2a}$.	11	1.4
13	Wrong transformation of correct coefficients along with the operations i.e. +ve and –ve sign for substitutions into the formula.	32	4.1
14	Inability to recognize that the denominators of the coefficient of x needed to be doubled before adding the square of the new coefficient to both sides of the equations.	39	5.0
15	Inability to understand the correct range of domains of x required to plot the graphs from the inequalities sign i.e. $<,\ >,\ \leq and \geq$	68	8.8
16	Wrong substitutions of the values of x at each interval in order to find the corresponding values of y	72	9.3
17	Wrong additions of individual values of terms in x^2, x and the constants in order to obtain the equivalent values of y that was used in plotting the graphs.	38	4.9
18	Inability to locate the correct origin through which the axes passed through in plotting the points.	29	3.7
19	Wrong transformation of data from the table to the correct plotting points on the graph sheet and joining them correctly	26	3.4
20	Inability to evaluate correctly from the graphs the values of y when values of x are given and vice- versa.	31	4.0
21	Wrong transformation of correct values calculated from the graphs to the answer sheets as a result of Carelessness.	54	7.0
22	Inability to differentiate +ve from –ve axes in leveling axes	57	7.4
23	Wrong used of scales in taken the range or intervals for the values of the axes	30	3.9
24	Inability to use same scales on both axes in plotting straight line graph on the quadratic graph	23	3.0
	Total	774	**100%**

From table 4.05, students committed more errors in the process skill which involved substitutions where students made, followed by errors in taking correct scale used in plotting the graph. Students committed less errors include in the used of quadratic formula which students were

conversion with 11(1.4%) and where students committed errors in transforming the operations of positive (+ve) and negative (-ve) sign with 15(1.9%).

Newman Errors were identified based on the tasks involved in the questions that were designed in the Newman errors diagnostic test (NEDT) given to the students to solve. The questions were drawn from the four components of quadratic equations. Six Newman errors were identified from each of the four different components of quadratic equations totaling twenty four. These Newman errors were the main focus of adapting the remediating package, Suchman inquiry-demonstration method.

Research Question 2: What is the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method?

In answering research question two, identified Newman errors obtained and presented in Table 4.05 were used and the data were classified into Newman errors types using in accordance with (Newman in Effandi & Siti 2010). Descriptive statistics using frequency and percentage was used in the analysis of the classified Newman errors types. Newman error committed by the students labeled as 1 was categorized as Read error, Comprehension errors comprises of serial numbers 2, 3, 12, 15 and 18. Transformation errors committed were represented as serial numbers 4, 6, 11, 13, and 19. Process skill errors represented serial number 5, 8, 10, 14, 16 and 17. Encoding errors were represented in serial number 21and 24. While Carelessness errors were represented in serial number 22 and 23. The frequency and percentage of Newman errors types committed by the students in quadratic equations were represented in Table 4.06.

Table 4.06 Frequency and Percentage Newman Error- types Committed by the Students in Quadratic Equation among Senior Secondary Students.

S/N	Newman Errors-Type	Frequency	Per. Freq. (%)
1	Reading Errors	091	11.76
2	Comprehension Errors	109	14.08
3	Transformation Errors	189	24.42
4	Process skill Errors	199	25.71
5	Encoding Errors	106	13.70
6	Carelessness	080	10.33
Total		**774**	**100.00**

The analysis in Table 4.06 indicated that the most frequent Newman errors committed by the students occurred in Process skill with 199 equivalents to 25.70%, followed by Transformation errors with 189 corresponding to 24.42%. The next high percentage errors committed was on Comprehension errors with 109 equivalents to 14.08%. Encoding errors followed with 106 that correspond to 13.70%. Reading errors committed by the students was 91 which was equivalent to 11.76% and the lastly Carelessness errors committed by the students was 80 equivalent to 10.34%. According to Prakitipong and Nakamura (2014) reading and comprehension errors where due to the problems of linguistics fluency and conceptual understanding that correspond with level of simple reading and understanding meaning of the problems. Transformation, Process skill and encoding answers were largely due to problems of mathematical processing. While most of the students committed comprehension and process skill errors (Norasiah, 2008). All the errors presented in Table 4.06 have been featured in the remediation package used as the treatment.

Research Question 3 What is the difference in the frequency of Newman errors committed by male and female students in quadratic equation among senior secondary schools?

Descriptive statistics of frequency and percentage was used in answering research question three. Classified Newman errors type presented in Table 4.6 was used in the analysis and the result was presented in Table 4.07.

Table 4.07 Frequency and Percentage of Newman error type identified in senior secondary students Newman errors Diagnostic Test on Gender

S/N	Newman Errors	N	Freq.	Male Freq.	Mean Male Freq.	Female Freq.	Mean Female Freq.
1	Reading		091	36(60.44%)	0.60	55(39.56%)	0.40
2	Comprehension		109	44(40.37%)	0.41	65(59.63%)	0.40
3	Transformation	186	189	88(46.56%)	0.47	101(53.44%)	0.53
4	Process Skill		199	96(48.24%)	0.48	103(51.76%)	0.52
5	Encoding		106	35(33.02%)	0.33	71(66.98%)	0.07
6	Carelessness		080	32(40.00%)	0.40	48(60.00%)	0.60
	Total		**774**	**331(42.76%)**	**2.49**	**443(57.24)**	**2.72**

From the result presented in Table 4.07, the six different types of Newman errors indicated differences between the male and female students. Reading errors types has 55(60.44%) for male and 36(39.56%) for female that showed that male students committed more of the reading errors than female. Female committed more of the comprehensions errors than male students with 65(59.44%) as against 44(40.37%) for the males. Errors committed in transformation with 88(46.56%) by the male and 101(53.44%) by the female implied that female committed more errors in transformation than male. Female committed more process skill errors with 103(51.76%) than male with 96(48.24%). Encoding errors were more committed by the female with 71(66.98%) than the male students with 35(33.02%). While errors committed as a result of carelessness by female was 48(60.00%) as against the male with 32(40.00%). The results in Table 4.07 indicated that male committed fewer errors than female. It was also observed that the mean percentage errors committed by female were slightly higher male percentage errors. Therefore, the results showed that there is difference in the frequency of Newman errors committed by the students in quadratic equations on the six Newman errors types. In summary, 774 total Newman errors were committed with 331 (42.76%) and 443 (57.24%) committed by male and female students with a mean

difference of 2.49 and 2.72 mean differences. The results indicated female committed more Newman errors than male.

Research Question 4 Does inquiry-demonstration method have impacts on the frequency of Newman errors-types committed by the students in solution process of quadratic equations?

To answer research question 4, the frequency of Newman errors types committed by the students in experimental and control groups pretest and posttest, was collected and used in the analysis. The result was presented in Table 4.08.

Table 4.08 Frequencies of Newman Error Types Pretest and Posttest levels on Newman Errors Diagnostic Test NEDT.

S/N	Newman Error Type	N	Pretest Freq.	Posttest Frequency	Frequency Difference	Frequency Per. (%)
1	Reading		051	40	11	9.8
2	Comprehension		063	46	17	15.2
3	Transformation	186	108	81	27	24.1
4	Process Skill		114	85	29	25.9
5	Encoding		061	45	16	14.3
6	Carelessness		046	34	12	10.7
	Total		**443**	**331**	**112**	**100**

From Table 4.08, the results indicated the frequency of Newman error types on pretest and posttest of the students on NEDT. The students in experimental group had mean frequency of 0.27 in pretest and 0.22 in posttest for reading errors while 0.34 and 0.25 were the mean frequencies for comprehension errors at pretest and posttest respectively. Mean frequency for transformation errors were 0.58 and 0.44 of pretest and posttest respectively. Process skill errors mean frequency indicated 0.61 and 0.46 the pretest and posttest. Encoding errors mean frequency of the pretest and posttest were 0.33 and 0.24 while the mean frequency in pretest and posttest for encoding errors

were 0.46 and 0.48 respectively. The differences in the frequencies were attributed to subjecting of experimental group to remediating package (inquiry-demonstration method).

4.2.3 Testing of Null Hypotheses

The following represents the four hypotheses tested at $p \leq 0.05$ level of significant

H_{01}: Null Hypothesis One

There is no significant difference in the frequency of different Newman Errors types Committed by the Students in quadratic equations.

In order to test null hypothesis one, the mean frequencies of the different types of Newman errors identified were used and subjected to Chi-square test and the results are presented in Table 4.09.

Table 4.09: Chi-Square results on Frequencies of Different Newman Error Types

S/N	Variable	N	F	Chi-cal	df	P	Remark
1	Reading		11.76				
2	Comprehension		14.08				
3	Transformation		24.42				
4	Process Skill	186	25.70	16.28	5	0.01	*
5	Encoding		13.70				
6	Carelessness		10.34				

*Significant at $p \leq 0.05$

The result in Table 4.09, the number of Newman Error types were six, and the degree of freedom for a 6 cell data correspond to 5 which was equivalent to (N-1), where N represent the total number of error, Chi-cal was 16.28. The P value obtained was 0.010 which was less than the significant level set at $p \leq 0.05$. The null hypothesis was therefore rejected. The results indicated that the

difference between the frequencies of different Newman error types was significant. Hence, the null hypothesis was rejected.

H_{O2}: Null Hypothesis Two

There is no significant difference in the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method.

The data collected for the analysis of hypothesis two H_{O2} were the frequencies of Newman errors types committed by SSII students in experimental and control groups during the posttest. The frequencies were subjected to a Chi-Square test for possible difference and or otherwise. The result of the analysis was presented in Table 4.10.

Table 4.10: Chi-Square test Result on Frequencies of Newman Error Types Committed by the students in Posttest

Group	N	Mean Frequency	Df	Chi-cal	P	Remark
Experimental	85	33.23	1	17.27	0.03	*
Control	101	66.77				

*Significant at $p \leq 0.05$

From the result in Table 4.10 indicated that the mean frequency for experimental and control groups were 33.23 and 66.77 respectively. The p value of 0.03 was obtained less than the level of significant at $p \leq 0.05$. Therefore, the null hypothesis three is rejected. That showed that there is significant difference in the frequency of Newman errors types committed by the students in experimental and control groups in favour of experimental group.

H_{03}: Null Hypothesis Three

There is no significant difference in the frequency of Newman errors committed by male and female students in quadratic equations exposed to inquiry-demonstration method.

The frequency of Newman error types committed by the experimental group and Gender in the posttest was obtained. The data was analyzed using Chi-Square to find the difference. The result was presented in Table 4.11.

Table4.11: Chi-Square test Result of Newman Error Types and Gender in Experimental group.

Group	N	Mean Frequency	Df	Chi-cal	P	Remark
Male	50	73.26				
			1	19.86	0.31	**
Female	35	33.23				

**Significant at $p \leq 0.05$

The result in Table 4.11 shows that the mean frequencies for male and female students were 73.26 and 73.23 respectively. The calculated P value was 0.31. The result indicated that P value is greater than level of significance at $p \leq 0.05$. Therefore; null hypothesis was retained showing that there is no significant difference in the Newman error types committed by the male and female students in experimental group. The reason may be attributed to exposure of the students to similar remediating package (inquiry-demonstration method). That further explained to the researcher that both male and female students benefited equally from the remediating package inquiry-demonstration method of teaching.

H_{04}: Null Hypothesis Four

There is no significant difference in the Performance among senior secondary students exposed to inquiry-demonstration and those exposed to lecture method.

The performance test scores for experimental and control groups were collected after pretest and posttest. However posttest performances of the groups were considered to test hypothesis four. The scores were subjected to t-test statistics of inferential statistics to test for the significant difference. The result of the analysis was presented in Table 4.12.

Table 4.12: t-test Analysis Results on Student's Performance Score in Experimental and Control Groups.

Variable Group	N	Mean	Std	def	t-cal	P-value	Remark
Experimental	85	55.93	12.39				
				238	-24.76	0.038	*
Control	101	20.26	9.78				

$*$ Significant at $P \leq 0.05$

The result presented in Table 4.12 showed that there was no significant difference in the performance of the experimental group and control group as supported by t-cal = -24.76 at def = 238 and p-value = 0.038 less than level of significance $\propto = 0.05$. The results indicated that there was no significant difference in the mean performance by the two groups in quadratic equation; hence null hypothesis one, which says that There is no significant difference in the mean performances of students taught quadratic equations using inquiry-demonstration method is rejected. The significant difference was in favour of those students exposed to inquiry-demonstration method as recorded in table 4.12.

4.3 Summary of Findings

The following are the findings of the study:

1. Hypothesis one indicated that there was a significant difference in the Newman error types committed by the students in quadratic equations taught using inquiry-demonstration method over those taught using lecture method. The findings on Newman errors showed that Newman errors committed by those taught using lecture method was more than the Newman errors committed by those students taught using inquiry-demonstration method in the solution process of quadratic equations.
2. The result of second hypothesis showed that there was a significant difference in the mean performance of students taught quadratic equations using inquiry-demonstration method over those taught same concepts using lecture method in favour of the experimental group.
3. The findings of the third hypothesis revealed that, there was no significant difference in the performance of male and female students in quadratic equations taught using inquiry-demonstration method, among the senior secondary students.
4. In hypothesis four the results indicated that, there was no significant difference in the mean performance scores of male and female students taught quadratic equation using lecture method.

4.4 Discussion of Results

The aim of this study is to assess the impact of inquiry-demonstration method on remediating Newman errors in quadratic equations and performance among senior secondary students in Kaduna state. The data collected from the test administered to the students were analyzed using descriptive and t-test statistics at $p \leq 0.05$ level of significance.

The results in tables 4.01, 4.02, 4.03, and 4.04 represented the results of pretest and posttest of experimental and control groups. The research questions were answered using frequency and percentage. Table 4.05 identified Newman errors committed by the students. Table 4.06 represent frequencies and percentages of Newman errors types committed by the students, process skill error recorded the highest with 25.70%, followed by Transformation errors with 24.42% while the least errors occurred in reading with 11.76% and errors committed as a result of carelessness 10.34%. Table 4.07 answered research question 3, where the frequency and percentage errors based on gender was presented with high errors committed by the female students. Table 4.08 was the results of research question 4, on the pretest and posttest experimental groups. Table 4.09 is the hypothesis 4 tested at 0.05 level of significant of the frequency of Newman errors using chi-square and the results indicated that there is significant difference with 0.010 probability value. The result was supported by the findings of Usman (2005) in his study on "the relationship between students' performance in practical activities and their academic achievements in integrated science using NISTEP mode of teaching" who observed that senior secondary male and female biology students will not differ significantly in their performance when exposed to innovative strategies. The findings also supported the previous studies such as that of Musa (2000), Azuka (2006), Tiawo (2007), Amoo (2010) and Martin (2011) who in their separate studies found that, the effect of laboratory teaching method for enhancing academic performance in chemistry among senior secondary school students was irrespective of gender. Obeka (2013) revealed that the use of innovative strategies in environmental education concepts of geography proved to be effective in enhancing the performance of male and female students and are gender friendly.

Table 4.10 using the same technique of analysis to test for the difference in the frequency and percentage the result showed that there is significant difference since the probability value of

0.03 was less than 0.05 level of significance. The findings supported the study of Sello (2006) who observed that students performed better when they are exposed to teaching strategies than those exposed to lecture method. Table 4.11 represents the results of male and female students' analyzed using chi-square test, with mean difference of 40.03. The probability value of 0.31 obtained was greater than 0.05 level of significant, which showed no significant difference on gender. Table 4.04 indicated a significant difference with 0.038 probability values and mean difference of 2.61, using t-test analysis on performance of students exposed to remediating package and those students taught using lecture method. The result was supported by the findings of Usman (2005) in his study on "the relationship between students' performance in practical activities and their academic achievements in integrated science using NISTEP mode of teaching" who observed that senior secondary male and female biology students will not differ significantly in their performance when exposed to innovative strategies. The findings also supported the previous studies such as that of Musa (2010), Azuka (2006), Amoo (2010) and Martin (2011) who in their separate studies found that the effect of laboratory teaching method for enhancing academic performance in chemistry among senior secondary school students was irrespective of gender. Obeka (2013) revealed that the use of innovative strategies in environmental education concepts of geography proved to be effective in enhancing the performance of male and female students and are gender friendly.

The results were in favour of experimental group, and were found to be significant at $p \leq 0.05$. The results of table 4.05 identified Newman errors committed by the students in experimental and control groups. The findings was in conformity with those previous researches on Newman Errors such as the one by Effandi. Ibrahim & Sitti (2014) in their studies on analysis of students errors in the learning process of quadratic equations observed that the used of teaching strategy, inquiry-demonstration method in identifying Newman errors minimized the errors

committed by the students in the learning process of quadratic equations. They went further to ascertain why and how? These errors are committed by using modified Newman interview and found that some of those who failed the written test answered the questions correctly after they were subjected to the interview. While others still failed the interview again and were given special attention, by using modified Newman interview method. However, their study was narrowed to only a sample of 32 junior secondary pupils that may not have covered the topics and survey method of data analysis was used only, which was not enough evidence to make conclusion on the level of Newman errors claimed to have committed by the students. While in this study four different methods of data analysis was adopted to arrive at the results presented. They include Frequency, Percentage, ANOVA, Chi-square and t-test statistics was used in the present study.

Sello (2010) observed that students exposed to inquiry method committed few errors and performed better when compared to those students exposed to lecture method, in his study on error diagnosis and performance learners made in solving quadratic equation by completing the square method. Hollander (2007) found that children exposed to demonstration method of teaching committed few errors than those subjected to lecture method of teaching, in his effort to investigate errors on written mathematics task. Prakitipong and Nakamura (2006) confirmed that students who were taught using guided- inquiry teaching method had better achievement scores and minimum number of errors than students who were taught same concept using lecture method. Joseph and Watson (2005) revealed same findi ngs using different teaching methods and observed same results that the used of those students exposed to teaching strategies committed few Newman errors and performed better than their counterparts that were subjected to lecture method of teaching. Obeka (2010) in an effort to find the effect of inquiry and demonstration methods on students achievement and retention in some environmental education concept of geography, observed that

students with the highest achievements scores are those exposed to inquiry method of teaching followed by those exposed to demonstration method and then those students exposed to lecture method of teaching. The study further revealed that inquiry and demonstration methods had highest effect on the overall achievements, interest and retention in environmental education concepts of geography students.

The findings also supported the study of Sello (2006) who observed that students performed better when they are exposed to teaching strategies than those exposed to lecture method. However, another finding of Usman (2005) revealed that many studies have pointed out that male students are academically superior to the female's counterparts in science, and further observed that the academic performance of male and female students in many situations depends on the school location, socio-economic background, the teacher qualifications, and learner's attitude, the mode of learning activities and sex of the learner. This contradicted the findings of Musa (2000) and Azuka (2006) which was stated before that, the effect of laboratory teaching method for enhancing academic performance in chemistry among senior secondary school students was irrespective of gender. Their studies agree with the findings of Amoo (2010), that there is no significant difference in the performance of boys and girls in mathematics and that they both perform equally well, which shows that there is gender imbalance in access to mathematics education at all levels of education. These conflicting results call for continuous investigations. The studies disagree with the recent studies by Busari (2005) which revealed that females are academically superior in mathematics and science. The study also disagree with the findings of Bolaji and Kajuru (2002) that revealed no gender difference in mathematics performance of male and female students. Variations in the mean performance scores of students taught quadratic equations correspondingly varied results based on varying null hypotheses, however, the hypotheses were rejected and was significant

difference in the mean Newman Errors and performances of the students taught quadratic equations using inquiry-demonstration method and those taught the same concept using lecture method and otherwise. The test revealed that the mean differences were in favour of experimental group. This showed that those students taught the concepts using inquiry-demonstration method performed significantly better than those students taught the same concepts of quadratic equation using lecture method. The significant differences found among the groups were likely due to the application of inquiry-demonstration method on the experimental group, the result wouldn't have been changed if the treatment was not administered. It implies that using inquiry-Demonstration in mathematics improves student's understanding of the mathematics' concepts. The results shows that the used of teaching strategy minimized Newman errors, improve students' performance and understanding of mathematics

CHAPTER FIVE

5.1 INTRODUCTION SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to investigate the Impact of Inquiry-Demonstration Method on Remediating Newman Errors and Enhancing Performance in Algebra among Senior Secondary School Students in Kaduna State, Nigeria. In this chapter, the methods used, in conducting the studies were described under the following sub-headings;

5.2 Summary

Chapter one of this study discussed on the background to the study that included various concepts and definitions of mathematics as opined by different authorities, statements of the problem, objectives of the study, research questions and null hypotheses, significant of the study, basic assumptions and scope/delimitations of the study. Four objectives, research questions and hypotheses were used to examine the impact of inquiry demonstration method on remediating Newman errors and enhancing performance in algebra among senior secondary school students and assessed the mean performance of male and female students in quadratic equations exposed to lecture method. The study was guided by four research questions and four hypotheses. The study was found to be significant to teachers, students' professional organizations, text books publishers, curriculum developers and host of others. The study was delimited to assessing of the impact of inquiry demonstration method on remediating Newman errors and performance among senior secondary students in Zaria education zone.

Chapter two of this study reviewed literatures related to this research work it also discussed the theoretical framework, mathematics as a teaching subject at senior secondary schools, concepts of teaching quadratic equations, the academic performance of students, errors on gender and

academic performance, overview of related studies and implications of reviewed literature on the present studies. Chapter three presented the methodology and the research design, which is quasi-experimental. The study was pretest-posttest quasi-experimental control group design. The population of the study covered all public senior secondary schools with total number of three thousand four hundred and ninety nine (3609) students. Students' of government secondary school Kaura Zaria and Government Secondary School Tudun Jukun Zaria in Kaduna state were used for the study. A sample of 186 SSII students were randomly selected from the sampled schools as at 2014/15 academic session in lined with the central limit theory and which was 5% of the population with 1% margin error in line with research advisors (2006) was selected to serve as sample of the study. Three validated instruments where two of them were developed by the researcher and adopted the other one were used for data collection, namely: Quadratic Equation Error Diagnostic Test QEEDT, Quadratic Equation Performance Test (QEPT) and Modified Newman Interview with reliability coefficient of 0.88, and 0.81 the data collected was subjected to descriptive and t-test statistical analysis.

Chapter four presented the results, analysis and discussions. Descriptive statistics was used to answer the research questions using frequency and percentage and chi-square was used to test for hypothesis one, two and three while t-test analysis of inferential statistics was used to test hypothesis four. The results indicated that there was a significant difference between the Newman errors and there was a significant difference on gender performance among the students taught quadratic equations using inquiry-demonstration and lecture methods of teaching. Chapter five presented the summary, findings, conclusion, contributions to knowledge, recommendations, limitations of the study and suggestions for further research. In this study therefore, the effectiveness of inquiry-demonstration teaching method on Newman errors and performance

among senior secondary students in Kaduna state were assessed and compared with similar errors and performance that was committed by the students thought using lecture method.

5.3 Summary of Major Findings

The study assesses the impact of inquiry -demonstration method on remediating Newman errors and performance among senior secondary students in Kaduna state. The major findings include the following.

1. There was a significant difference between the frequencies of Newman errors committed by the students in the solution process of quadratic equation among senior secondary students. The significant difference in the frequencies of Newman errors committed by the students in the solution process of quadratic equations indicated more errors committed in process skill, followed by transformation and the least errors committed was on reading and carelessness.
2. There is a significant difference in the frequency of Newman errors committed by students in the solution process of quadratic equations exposed to inquiry-demonstration method and those exposed to lecture method. The frequencies of errors committed by those students exposed to remediating package were fewer than those exposed to lecture method.
3. There is no significant difference between the frequencies of Newman errors committed by male and female students in the solution process of quadratic equations exposed to inquiry-demonstration method. The result revealed that there was no gender difference.
4. There is no significant difference between the frequencies of Newman errors committed by the students in the solution process of quadratic equations and performance of the students taught using inquiry-demonstration method.

5.4 Conclusions

From the findings of this study, the following conclusions were drown

1. Instructional strategies that researcher use in the solution process of quadratic equations have significant effects on the students' performance compared to lecture method.
2. Inquiry- demonstration method of teaching facilitated effective learning in the solution process of quadratic equation compared to lecture method, and improve their performance.
3. Students who were taught quadratic equations using inquiry demonstration method of teaching showed no difference in the mean performance of students in the solution process of quadratic equations.
4. The mean performance scores of male and female students taught quadratic equation using lecture method indicated no gender difference.

5.5 Contributions to Knowledge

The following were the contributions to knowledge which this study has added to the existing literature.

1. The instructional strategy, Inquiry-Demonstration method has been improved from six steps to eight steps. This will help the teaching and learning of quadratic equation in algebra and mathematics in general.
2. The uniqueness of this study made it to be an area where no exactly the same study was conducted in the recent time. However, related research works have been reviewed accordingly i.e. the study on Newman errors other than related errors was relatively few.
3. The used of a remediating package 'Inquiry-Demonstration' will help teachers and students in understanding and minimized Newman errors in the solution process of quadratic equation in algebra.
4. Modification of 'Modified Newman interview method' to Modified Newman Interactive Schedule was another achievement of the present study. Because it was a face to face

interaction which was a taught process to confirm why? And how? The Newman errors were committed. The used of this schedule was relatively new in comparisons with other related studies.

5. Professional organizations like MAN, STAN, mathematics educators' will find the new teaching strategy very useful and promote mathematics instruction.

5.6 Recommendations

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

1. The researcher recommended that this study can be carried out elsewhere using same or different population and sample size on remediating Newman errors that lead to poor performance of students in mathematics in order to improve on the existing work.
2. The teaching of Algebra in mathematics should be conducted in such a way that students effectively learn the concepts presented to them and the use of inquiry demonstration method of teaching seems to be appropriate in that respect. It should, therefore be incorporated into the main stream of pedagogy in the teaching of algebra in mathematics in the senior secondary schools curriculum.
3. The use of lecture method has been found to be ineffective in this study, with respect to students' Newman errors and performance in the solution process of quadratic equations. Therefore, inquiry demonstration method of teaching should be encouraged and the use of lecture method should be with caution or discouraged completely.
4. Equal opportunity should be given to both male and female students in the learning process of algebra in mathematics, using teaching strategies which include inquiry-demonstration method. That will enhance students' performance.
5. Federal Government of Nigeria through state ministries of education should collaborate with professional bodies such as MAN, STAN to organized training programs for teachers

teaching mathematics in form of seminars, workshops and conferences and focused more on the use of inquiry demonstration method of instructional strategies in the teaching of the concepts of algebra in mathematics.

5.7 Limitations of the Study

This study has the following limitations

1. High sample size of the students due to the use of intact classes made it difficult for the researcher to use the instructional strategies effectively.
2. Poor attitude of some students towards learning especially the control group contributed to their poor performance.
3. Another problem difficulties faced by the researcher distinguishing the Newman errors after pilot testing due to nature of approaches by the students in solving problems.
4. Those students who were exposed to Modified Newman Interview i.e. students who failed the written test took much of the time to be carried along, in the procedure to understand why and how? The errors were committed.

5.8 Suggestions for Further Research

This study can further be extended in the following ways:

1. By conducting similar study, which will focus on the solution process of other algebraic equations or expressions or both in mathematics using inquiry-demonstration method of teaching, with the view to find out whether similar or different result could be obtained.
2. This study can be extended to other senior secondary schools to carryout similar study using the teaching strategy inquiry-demonstration method of instruction in order to improve on teaching of algebra and minimized Newman errors in mathematics.

3. The scope can be extended to junior secondary schools students and compare with senior secondary schools students, on the suitability of inquiry demonstration method of instruction.
4. A research fellow who may wish to go through this study, in an effort to come up with a topic of research can increase the variables from three to four, together with the components of the research i.e. by adding graphical method to find out the Newman errors students may likely committed in the solution process of quadratic equations.

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APPENDIX A

LESSON PLAN FOR

EXPERIMENTAL GROUP

(USING INQUIRY DEMONSTRATION METHOD)

LESSON 1

Group**:**	Experimental (Inquiry Demonstration)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using Factorization Method
Instructional Material**:**	New General Mathematics for Senior Secondary Schools book
Behavioral Objectives**:**	By the end of the Lesson, students should be able to factorize quadratic equations using factorization method.
Previous Knowledge**:**	Students have been able to factorize quadratic equation using the general quadratic equation $ax^2 + bx + c = 0$
Presentation Rule A:	Introduction**:** The researcher introduces the lesson by engaging the students in an exploration of problem staged through demonstration and inquiry by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session was devoted to the students, asking questions and demonstrating in order to gather enough data which they will use to formulate their theories i.e. to find the factors required for factorization and later evaluate for the variables. Some of the problems explored by the students include:

(a) $x^2 + 2x – 8 = 0$ (b) $x^2 + x – 6 = 0$ (c) $2x^2 + 5x + 3 = 0$

Presentation Rule 1: Questioning**:** The researcher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no**,** So that the burden of thinking will be shifted to the students. The teacher expects them to come up with an idea based on the previous knowledge of factorization of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule 2: Freedom to Ask Questions: The researcher allows the students to ask as many questions as possible once they stated. This is to encourage the students to use their previous questions to formulate new ones in order to pursue a reasonable theory. The climate of the classroom was made to poster the axiom "that there are no dumb questions". The researcher answer all questions raised by the students**,** in their efforts to form factors of a given quadratic equation that was used to factorize the equation i.e. $x^2 – 2x – 8 = 0$. The possible factors are obtained as follows

Multiply x^2 by -8 to get $-8x^2$. The various factor of $-8x^2$ includes -2x and 4x, -4x and 2x, -x and 8x and -8x and x. out of these factors -4x and 2x is the required factor because sum of the numbers formed the middle number in the given equation. It is obtained by adding -4x + 2x = -2x.

Presentation Rule 3: Researcher response to Statement of Theories. The teacher refrained from evaluating the student's theories when they have presented to him. Rather he either records the theories on the board or asks questions about the theories. E.g. the different alternatives of theories or factors obtained from the given equation.

$2x^2 + x – 1 = 0$ the various are -2x and x, or -x and 2x.

The required factor is –x and 2x.

Presentation Rule 4: Testing Theories: The researcher asks the students to test their theories at any time i.e. the different factors they thought and select

the required factors, while the researcher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The researchers response was always yes or no. That will help the students to know whether their formulated theories are correct or wrong. For example, a student is required to factorize the quadratic equation, $x^2 + 8x + 15 = 0$.

The product of x^2 and 15 gives $15x^2$

The different factors of the equation include 3x and 5x, -3x and 5x, -x and -15x, x and 15x Students tested each factor in an effort to find the correct one, and letter used them to factorize the equation and find the values of x which is $X^2 + 8x + 15 = 0$ The correct factor is 3x and 5x

I.e. $x^2 + 3x + 5x + 15 = 0$

Factorizing the first two groups and the second two groups

$x(x+3) + 5(x + 3) = 0$

Re-factorizing to get

$(x +3) (x + 5) = 0$

Either $x + 3 = 0$ or $x+5 = 0$

i.e $\underline{x = -3}$ or $\underline{x= -5}$

Presentation Rule 5:

Cooperation**:** The researcher observed different results of the students and encouraged them to work as a team in order to confer and discuses their actors. The teacher gives four different problems to four different groups to make inquiries and demonstrate how each can be factorized, and find the values of x.

Group A	Group B
$2x^2 – x – 1 = 0$	$x^2 + x – 2 = 0$

Mult, $2x^2$ by -1	Mult. x^2 by -2
To have $-2x^2$	to have $-2x^2$
The factors of $-2x^2$ are	$-2x^2$ are
-2x and x, 2x and –x	-2x and x, 2x and –x
The correct factor is -2x & x	the factor is 2x and -x
So that, $2x^2$ -2x + x – 1 = 0.	then, x^2 + 2x – x – 2 = 0
Factorizing L.H.S we have	factorizing L.H.S we have
2x(x – 1) + (x – 1) = 0	x(x + 2) – (x + 2) = 0
Re – factorizing we have	Re–factorizing
(x – 1) (2x + 1) = 0	(x + 2) (x – 1) = 0
Either, x - 1 = 0 or 2x + 1 = 0	x + 2 = 0 or x – 1 = 0
Then, x = 1 or x = - ½	then, x = -2 or x = 1
Group C	Group D
$4x^2$ – 8x + 3 = 0	x^2 + 7x – 10 = 0
Mult, 4x2 by 3	mult x^2 by -10
To have $12x^2$	to have $-10x^2$
The factors of $12x^2$ are	the factors of $-10x^2$
6x and 2x, -6x and –2	2x and 5x, -2x and –5x
x and 12x, -x and -12x	
The correct factor is -6x and -2x	factor is 2x and 5x
So that $4x^2$ -6x - 2x + 3 = 0.	X^2 + 5x +2x + 10 = 0

Factorizing L.H.S we have	factorizing L.H.S
$2x(2x - 3) - (2x - 3) = 0$	$x(x + 5) - 2(x + 5) = 0$
Re – factorizing we have	Re – factorizing
$(2x - 3)(2x - 1) = 0$	$(x - 2)(x + 5) = 0$
Either, $2x - 3 = 0$ or $2x - 1 = 0$	either, $X-2 = 0$ or $x + 5$
Then, $x = 3/2$ or $x = ½$	then, $x = 2$ or $x = -5$

Presentation Rule 6: Experimenting: The researcher provides materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The researcher evaluates the lesson by asking the students to factorize the following class exercise.

(i) $3x^2 + 4x + 3 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion: The researcher concludes the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories or factors. The factors are then used to factorize the equations

LESSON 2

Group**:**	Experimental (Inquiry Demonstration)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation `
Topic:	Solutions of Quadratic Equations using completing the Square Method
Instructional Material**:**	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives**:**	By the end of the Lesson, students should be able to find the solutions of quadratic equation using completing the square method
Previous Knowledge**:**	Students have been able to use completing the square method to find the solutions of the general formula of quadratic equation using completing the square method. i.e $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ the relation is derived from $ax^2 + bx + c = 0$, as follows.

Equating the relation to the constant c, we have

$x^2 + bx = -c$

Dividing both sides of the equation by a

$x^2 + \frac{b}{a}x = -\frac{c}{a}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{b}{a}x + (\frac{b}{2a})^2 = -\frac{c}{a} + (\frac{b}{2a})^2$

$(x + \frac{b}{a})^2 = \frac{b2}{4a2} - \frac{c}{a}$

$x + \frac{b}{a} = \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

Expanding L.H.S of the equation we have

$x = -\frac{b}{a} \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

$x = -\frac{b}{a} \pm\sqrt{\frac{b2-4ac}{4a2}}$

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

Either, $x = \frac{-b+\sqrt{b^2-4ac}}{2a}$ or $x = \frac{-b-\sqrt{b^2-4ac}}{2a}$

Introduction Rule A: The researcher introduced the lesson by engaging the students in an exploration of problem staged through demonstration and inquiry by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session is devoted to the students, asking questions in order to gather enough data which they will use to formulate their theories i.e. to evaluate the equation using completing the squares method we need to follow the same procedure applied in the previous knowledge. Some of the problems include:

(a) $x^2 + 2x - 8 = 0$ (b) $x^2 + x - 6 = 0$ (c) $2x^2 + 5x + 3 = 0$

Presentation Rule 1: Questioning: The teacher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no, So that the burden of thinking will be shifted to the students. The teacher expects them to come up with an idea based on the previous knowledge of completing the square method of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule2: Freedom to ask questions: The researcher allowed the students to ask as many questions as possible once they stated. This is to encourage the students to use his or her previous questions to formulate new

ones in order to pursue a reasonable theory. The climate of the classroom was made in such away to poster the axiom "that there are no dumb questions". The teacher answered all questions asked by the students. The normal procedure of dividing both sides of the equation by the coefficient of x2 was maintained. Then doubling the denominator of the coefficient of x and adding its square to both sides of the equation. L.H.S of the equation was factorized in order to obtain the values of x, as seen below. One of the groups of students asks is this the procedure of evaluating this equation $x^2 + 2x - 8 = 0$ using completing the square method? Etc.

Equating the relation to the constant c, we have

$x^2 + 2x = 8$

Dividing both sides of the equation by 1

$x^2 + \frac{2}{1}x = \frac{8}{1}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{2}{1}x + (\frac{2}{2})^2 = \frac{8}{1} + (\frac{2}{2})^2$

$(x + 1)^2 = \frac{8}{1} + 1$

$x + 1 = \pm\sqrt{(8 + 1)}$

Expanding L.H.S of the equation we have

$x = -1 \pm \sqrt{(9)}$

$x = -1 \pm 3$

Either $x = -1 + 3$ or $x = -1 - 3$

Either, $x = 2$ or $x = -4$

Presentation Rule 3: Researcher Response to Statement of Theories. The teacher refrained from evaluating the student's theories when they presented their theories. Researcher records the student's theories on the board or asks questions about the theories. Examples of the theories include, taking the constant c to the right hand side of the equation, ability to divide both sides of the equation by a, ability to doubled the coefficient of the denominator of x and add its square to both sides of the equation in order to find the values of x. Alternatively, Teacher ask the students are you to divide both sides of the equation by a?. Did you transfer the constant to the other sides of the equation? Are you supposed to take the square roots of both sides? E.t.c.

Presentation Rule 4: Testing Theories: The researcher ask the students to test their theories at any time i.e. the different factors they thought are the required factors, while the researcher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The teacher's response was always, yes or no. That will help the students to know whether their formulated theories are correct or wrong. For example, a student test the theories by evaluating x2 + 8x +15 = 0 for values of x Using completing the square method. Equating the relation to the constant c, we have

$x^2 + 8x = -15$

Dividing both sides of the equation by 1

$x^2 + \frac{8}{1}x = -\frac{15}{1}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{8}{1}x + (\frac{8}{2})^2 = -\frac{15}{1} + (\frac{8}{2})^2$

Expanding L.H.S of the equation we have

$(x + 4)^2 = -\frac{15}{1} + (4)^2$

$x + 4 = \pm\sqrt{(-15 + 16)}$

$x = -1 \pm \sqrt{(1)}$ or $x = -1 \pm 1$

Either $x = -1 + 1$ or $x = -1 - 1$

Either, $x = 0$ or $x = -2$

Presentation Rule 5: Cooperation: The researcher observed the students and encouraged them to work as a team in order to confer and discuses their theories. The researcher gave four different problems to four different groups to make inquiries and demonstrate how each can be solved using completing the square method, and find the values of x.

Group A	Group B
$2x^2 - x - 1 = 0$	$x^2 + x - 2 = 0$
Equating to the constant	equating to the constant
$2x^2 - x = 1$	$x^2 + x = 2$
Dividing both sides by 2	dividing both sides by 1 then,
$x^2 - \frac{1}{2}x = \frac{1}{2}$	$x^2 + \frac{1}{1}x = \frac{2}{1}$
Adding $(-\frac{1}{2})2$ to both sides	adding $(\frac{1}{2})2$ to both sides
$x^2 - \frac{1}{2}x + (-\frac{1}{2})2 = \frac{1}{2} + \left(\frac{1}{2}\right)2$	$x^2 + \frac{1}{1}x + (\frac{1}{2})2 = \frac{2}{1} + \left(\frac{1}{2}\right)2$
Factorizing L.H.S	Factorizing L.H.S then,
$(x - \frac{1}{2})^2 = \frac{1}{2} + (\frac{1}{2})2$	$(x + \frac{1}{2})^2 = \frac{2}{1} + \left(\frac{1}{2}\right)2$
Square root of both sides	taking square root of b. sides

$x - \frac{1}{2} = \pm\sqrt{(\frac{1}{2} + \frac{1}{4})}$ so that,

$x = \frac{1}{2} \pm\sqrt{(\frac{2+1}{4})}$ so that,

$x = \frac{1}{2} \pm\sqrt{(\frac{3}{4})}$

$x = 1 + \sqrt{(\frac{3}{4})}$

x = 1 + 0.43 or x = 1- 0.43

<u>x = 1.43</u> or <u>x = 0.57</u>

$x + \frac{1}{2} = \pm\sqrt{(\frac{2}{1} + \frac{1}{4})}$ so that,

$x = -\frac{1}{2} \pm \sqrt{(\frac{8+1}{4})}$ so that,

$x = -\frac{1}{2} \pm \sqrt{(\frac{9}{4})}$ so that,

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

x = 0.5 +1.5 or 0.5 – 1.5

<u>x = 2</u> or <u>x = 1</u>

<u>Group C</u>

$4x^2 + 4x - 3 = 0$

Equating to the constant

$4x^2 + 8x = 3$

Dividing both sides by 4

$x^2 - \frac{8}{4}x = \frac{3}{4}$

Adding $(-\frac{8}{8})2$ to both sides

$x^2 - \frac{8}{4}x + (-\frac{8}{8})2 = \frac{3}{1} \pm (-1)(-1)$

Factorizing L.H.S

$(x - 1)^2 = \frac{3}{1} + (1)$

Taking square root of B.S

$x - 1 = \pm\sqrt{(1 + \frac{3}{1})}$ so that,

<u>Group D</u>

$x^2 + 7x - 10 = 0$

equating to the constant then,

$x^2 + 7x = 10$

dividing both sides by 1 then,

$x2 + \frac{7}{1}x = \frac{10}{1}$

adding $(\frac{7}{2})2$ to both sides

$x^2 + \frac{1}{1}x + (\frac{7}{2}) = \frac{10}{1} + \left(\frac{7}{2}\right)2$

Factorizing L.H.S then,

$(x + \frac{7}{1})^2 = \frac{10}{1} + \left(\frac{7}{2}\right)2$

taking square root of

$x + \frac{7}{1} = \pm\sqrt{(\frac{10}{1} + \frac{49}{4})}$

$x = \frac{1}{2} \pm \sqrt{(\frac{1+3}{1})}$ so that,

$x = -\frac{7}{1} \pm \sqrt{(\frac{40+49}{4})}$ so that,

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

$x = -\frac{1}{2} \pm \sqrt{(\frac{89}{4})}$ so that,

$x = \frac{1}{2} + 2$ or $x = \frac{1}{2} - 2$

$x = -\frac{1}{2} \pm 9.43$

$x = 2.5$ or $x = -1.5$

$x = -0.5+9.4$ or $x = -0.5-9.4$

Presentation Rule 6: Experimenting: The researcher provide materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The researcher evaluates the lesson by asking the students to find the values of the following quadratic equation using completing the square method.

(i) $3x^2 + 4x + 3 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion: The researchers conclude the lesson by going round to observe what the students have done after making all inquiries.

LESSON 3

Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations Using Quadratic Formula.
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives:	By the end of the Lesson, students should be able to find the solutions of quadratic equation using quadratic formula.
Previous Knowledge:	Students have been able to use the general quadratic equation using completing the square method to derive the quadratic formula i.e $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ the relation is derived from $ax^2 + bx + c = 0$, as follows.

Equating the relation to the constant c, we have

$x^2 + bx = -c$

Dividing both sides of the equation by a

$x^2 + \frac{b}{a}x = -\frac{c}{a}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{b}{a}x + (\frac{b}{2a})\,2 = -\frac{c}{a} + (\frac{b}{2a})^2$

$(x + \frac{b}{a})^2 = \frac{b2}{4a2} - \frac{c}{a}$

$x + \frac{b}{a} = \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

Expanding L.H.S of the equation we have

$x = -\frac{b}{a} \pm \sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

$x = -\frac{b}{a} \pm \sqrt{\frac{b2-4ac}{4a2}}$

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

Either, $x = x = \frac{-b+\sqrt{b^2-4ac}}{2a}$ or $x = x = \frac{-b-\sqrt{b^2-4ac}}{2a}$

Introduction Rule A: The researcher introduced the lesson by engaging the students in an exploration of problem staged through inquiry-demonstration and by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session is devoted to the students, asking questions in order to gather enough data which they will use to formulate their theories i.e. to evaluate the equation using completing the squares method we need to follow the same procedure applied in the previous knowledge. Some of the problems include:

(a) $x^2 + 2x - 8 = 0$ (b) $x^2 + x - 6 = 0$ (c) $2x^2 + 5x + 3 = 0$

Presentation Rule 1: Questioning: The researcher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no, So that the burden of thinking will be shifted to the students. The researcher expects them to come up with an idea based on the previous knowledge of completing the square method of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule2: Freedom to ask questions: The researcher allowed the students to ask as many questions as possible once they stated. This is to encourage the students to use his or her previous questions to formulate new ones in order to pursue a reasonable theory. The climate of the classroom must be made in order to poster the axiom "that there are

no dumb questions". The researcher resisted all questions raised by the students. The normal procedure of dividing both sides of the equation by the coefficient of x^2 was maintained. Then doubling the denominator of the coefficient of x and adding its square to both sides of the equation. Left hand side of the equation was factorized in order to obtain the values of x, as seen below. One of the groups of students asks, Is it the procedure of evaluating this quadratic equation $x^2 + 2x - 8 = 0$ using the general formula?

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

Comparing the coefficients of x^2, x and c with $ax^2 + bx + c$, thus,

a = 1, b = 2 and c = -8.

Substituting the values in the equation we have

$x = \frac{-2 \pm \sqrt{2^2 - 4 \text{ x } 1 \text{ x} -8}}{2 \, x \, 1}$

$x = \frac{-2 \pm \sqrt{(4 + 32)}}{2}$

$x = \frac{-2 \pm \sqrt{36}}{2}$

$x = \frac{-2 \pm 6}{2}$

Either, $x = -\frac{2+6}{2}$ or $x = \frac{-2 - 6}{2}$

$x = \frac{4}{2}$ or $x = \frac{8}{2}$

x = 2 or x = 4

Presentation Rule 3: Teacher Response to Statement of Theories. The researcher refrained from evaluating student's formulated theories. Teacher records the student's theories on the board or ask questions about the theories. Examples of the theories set by the students include, can I compare

the coefficients of a, b, and c with the given equation in order to substitute the values in the general formula? The researcher asked is that how you will compare the coefficients of the variables? Etc.

Presentation Rule 4: Testing Theories: The researcher ask the students to test their theories at any time in order to know the required coefficients, while the teacher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The researchers response is always, yes or no. That will help the students to know whether their formulated theories are correct or wrong. For example, a student test the theories by evaluating $x^2 + 8x +15 = 0$ for values of x the general formula.

Comparing the variables with the coefficient of the given equation

Thus, and substituting the values in the general formula,

a = 1, b = 8 and c = 15

$$x = - \frac{b \pm \sqrt{(b2 - 4ac)}}{2a}$$

$$x = \frac{-1 \pm \sqrt{(82 - 4\ x\ 1\ x\ 15)}}{2\ x\ 1}$$

$$x = \frac{-1 \pm \sqrt{(82 - 60)}}{2}$$

$$x = - \frac{1 \pm \sqrt{(22)}}{2}$$

$$x = - \frac{1 \pm 4.69}{2}$$

Either, $x = - \frac{1 + 4.69}{2}$ or $x = \frac{-1 - 4.69}{2}$

$x = \frac{3.69}{2}$ or $x = \frac{-5.69}{2}$

x = 1.845 or x = -2. 845

Presentation Rule 5: Cooperation: The researcher observed the students and encouraged them to work as a team in order to confer and discuses their theories. The researcher gave four different problems to four different groups to make inquiries and demonstrations on how each can be used to formulate new theories, in order to find the values of x using quadratic formula

Group A	Group B
$2x^2 - x - 1 = 0$	$x^2 + x - 2 = 0$
Comparing coefficients	comparing coefficients
a = 2, b = -1 and c = -1	a = 1, b = 1 and c = -2
Subst. values in the eqn.	Subst. values then equation
$x = \frac{--1 \pm \sqrt{-1^2 - 4 \text{ x } 2 \text{ x} -1}}{2 \, x \, 2}$	$x = \frac{-1 \pm \sqrt{1^2 - 4 \text{ x } 1 \text{ x} -2}}{2 \, x \, 1}$
$x = 1 \pm \sqrt{\frac{1+8}{4}}$	$x = \frac{-1 \pm \sqrt{1+8}}{2}$
$x = \frac{1 \pm \sqrt{9}}{4}$	$x = \frac{-1 \pm \sqrt{9}}{2}$
Either, $x = \frac{1+3}{4}$ or $x = \frac{1-3}{4}$	$x = \frac{-1+3}{2}$ or $x \frac{= -1-3}{2}$
$x = 1$ or $x = -\frac{1}{2}$	either, x = 2 or x = -2
Group C	Group D
$4x^2 + 4x - 3 = 0$	$x^2 + 7x - 10 = 0$
Comparing coefficients	comparing coefficients
a = 4, b = 4 and c = -3	a = 1, b = 7 and c = -10
Subst. the values in the eqn	Subst. values then equation

$x = \frac{-4 \pm \sqrt{4^2 - 4 \text{ x } 4 \text{ x} -3}}{2\ x\ 4}$ $x = \frac{-7 \pm \sqrt{7^2 - 4 \text{ x } 1 \text{ x} - 10}}{2\ x\ 1}$

x =$-4 \pm \sqrt{\frac{16+48}{8}}$ $x = \frac{-7 \pm \sqrt{49+40}}{4}$

x = $\frac{16 \pm \sqrt{65}}{8}$ x = $\frac{-7 \pm \sqrt{89}}{4}$

Either, x = $\frac{16 + 8.06}{8}$ or x = $\frac{16 - 8.06}{8}$ x=$\frac{-7+9.43}{4}$or x $\frac{-7-9.43}{4}$

x = $\frac{25.06}{8}$ or x = -$\frac{7.06}{8}$ either, x = - $\frac{2.43}{4}$ or x = - $\frac{16.43}{4}$

x = 3.13 or x = 0.8 x = -0.61 or x = -4.11

Presentation Rule 6: Experimenting: The researcher provide materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The teacher evaluates the lesson by asking the students to find the values of the following quadratic equation using quadratic formula

(i) $3x^2 + 4x + 3 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion: The researcher conclude the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories which are then used to evaluate for using quadratic formula.

LESSON 4

Group**:** Experimental (Inquiry-Demonstration)

Class: SSSII

Time: 2Hours

Subject Area: Quadratic Equation

Topic: Solutions of Quadratic Equations using Graphical Method

Instructional Material**:** New General Mathematics for Senior Secondary Schools book

Behavioral Objectives**:** By the end of the Lesson, students should be able to draw a quadratic graph using graph sheet.

Previous Knowledge**:** Students have been able to draw a linear or straight line graph

Presentation Rule A: Introduction**:** The researcher introduces the lesson by engaging the students in an exploration of problem staged through demonstration and inquiry by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session was devoted to the students, asking questions and demonstrating in order to gather enough data which they will use to formulate their theories i.e. to calculate the values of y given the corresponding values of x in order to plot the values on the graph sheet, and join the point to produce the curve otherwise known as parabola or belt in shape. Some of the problems explored by the students include:

(a) $x^2 + 2x - 3 = 0$ (b) $x^2 + 5x - 6 = 0$ (c) $x^2 + 5x + 6 = 0$

Presentation Rule 1: Questioning**:** The researcher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no**,** So that the burden of thinking will be shifted to the students. The teacher expects them to come up with an idea

based on the previous knowledge of plotting graphs of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule 2: Freedom to Ask Questions: The researcher allows the students to ask as many questions as possible once they stated. This is to encourage the students to use their previous questions to formulate new ones in order to pursue a reasonable theory. The climate of the classroom was made to poster the axiom "that there are no dumb questions". The researcher answers all questions raised by the students**,** in their efforts to evaluate for values of y given values of x in the quadratic equation i.e. $x^2 + 2x - 3 = 0$.

Presentation Rule 3: the researcher response to Statement of theories. The researcher refrained from evaluating the student's theories when they have presented to him. Rather he either records the theories on the board or asks questions about the theories. E.g. the different alternatives of theories or values of y for which values of x were given from the equation.

Presentation Rule 4: Testing Theories: The researcher asks the students to test their theories at any time i.e. the different values of y for which x is given were obtained they thought and calculate the required values of y, while the researcher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The researcher response was always yes or no. That will help the students to know whether their formulated theories are correct or wrong.

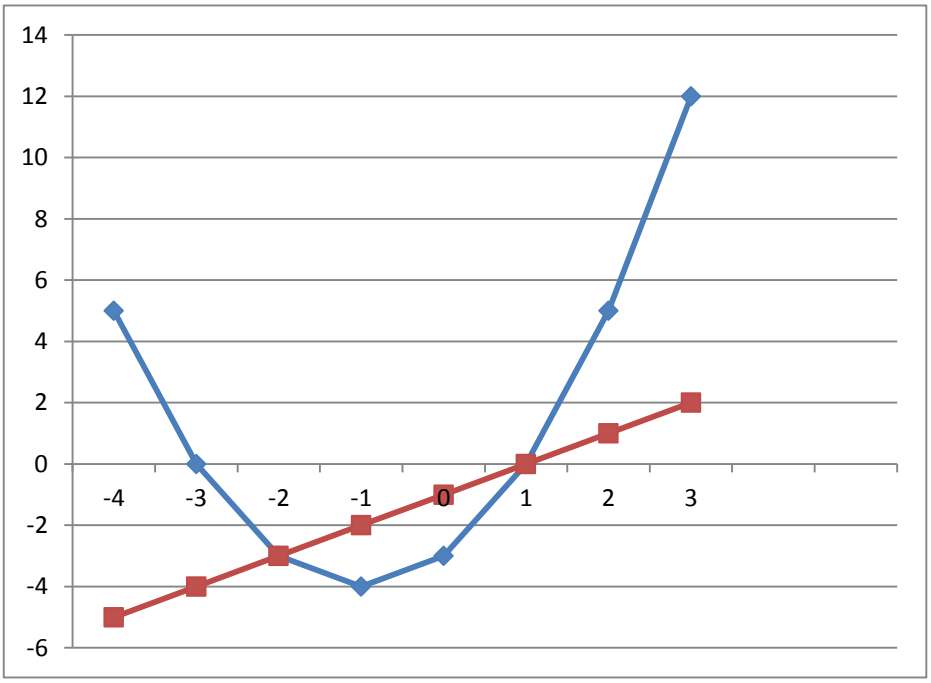
E.g. Students were asked to plot the graph of $y = x^2 + 2x - 3$ each for which values of x between -4 to +3 was indicated in inequality form $-4 \leq x \leq 3$. using a scale of 1cm to I unit on both axes. Using the same scale and axes plot the graph of $y = x - 1$. Find the points of intersection of the two the curve and the straight line. Students have two methods i.e. by either substituting each value of x directly in the

equation or putting the values on a table and find the values of each number of the given quadratic equation. For the purpose of celerity and shortest possible way of calculating the corresponding values of y table of values was used.

$y = x^2 + 2x - 3$ and the domain of x are $-4 \leq x \leq 3$

Scale: 1cm to 1unit on box axes

X	-4	-3	-2	-1	0	1	2	3
X^2	16	9	4	1	0	1	4	9
2x	-8	-6	-4	-2	0	2	4	6
-3	-3	-3	-3	-3	-3	-3	-3	-3
Y_1	**5**	**0**	**-3**	**-4**	**-3**	**0**	**5**	**12**
X	-4	-3	-2	-1	0	1	2	3
-1	-1	-1	-1	-1	-1	-1	-1	-1
Y_2	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**



Presentation Rule 5: Cooperation**:** The teacher observed different results of the students and encouraged them to work as a team in order to confer and discuses their actors. The teacher gives four different problems to four different groups to make inquiries and demonstrate how each can be factorized, and find the values of x

Presentation Rule 6: Experimenting: The teacher provides materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The teacher evaluates the lesson by asking the students to factorize the following class exercise.

(i) $x^2 + 5x + 6 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion: The teacher concludes the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories or factors. The factors are then used to factorize the equation

LESSON 5

Group**:**	Experimental (Inquiry-Demonstration)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation `
Topic:	Solutions of Quadratic Equations using completing the Square Method
Instructional Material**:**	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives**:**	By the end of the Lesson, students should be able to find the solutions of quadratic equation using completing the square method
Previous Knowledge**:**	Students have been able to use completing the square method to find the solutions of the general formula of quadratic equation using completing the square method. i.e $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ the relation is derived from $ax^2 + bx + c = 0$, as follows.

Equating the relation to the constant c, we have

$x^2 + bx = -c$

Dividing both sides of the equation by a

$x^2 + \frac{b}{a}x = -\frac{c}{a}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{b}{a}x + (\frac{b}{2a})^2 = -\frac{c}{a} + (\frac{b}{2a})^2$

$(x + \frac{b}{a})^2 = \frac{b2}{4a2} - \frac{c}{a}$

$x + \frac{b}{a} = \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

Expanding L.H.S of the equation we have

$x = -\frac{b}{a} \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

$x = -\frac{b}{a} \pm\sqrt{\frac{b2-4ac}{4a2}}$

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

Either, $x = \frac{-b+\sqrt{b^2-4ac}}{2a}$ or $x = \frac{-b-\sqrt{b^2-4ac}}{2a}$

Introduction Rule A: The researcher introduced the lesson by engaging the students in an exploration of problem staged through demonstration and inquiry by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session is devoted to the students, asking questions in order to gather enough data which they will use to formulate their theories i.e. to evaluate the equation using completing the squares method we need to follow the same procedure applied in the previous knowledge. Some of the problems include:

(a) $x^2 - 3x + 2 = 0$ (b) $x^2 - 5x + 4 = 0$ (c) $2x^2 - 7x + 5 = 0$

Presentation Rule 1: Questioning: The researcher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no, So that the burden of thinking will be shifted to the students. The researcher expects them to come up with an idea based on the previous knowledge of completing the square method of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule2: Freedom to ask questions: The teacher allowed the students to ask as many questions as possible once they stated. This is to encourage the students to use his or her previous questions to formulate new ones

in order to pursue a reasonable theory. The climate of the classroom was made in such away to poster the axiom "that there are no dumb questions". The researcher answered all questions asked by the students. The normal procedure of dividing both sides of the equation by the coefficient of x2 was maintained. Then doubling the denominator of the coefficient of x and adding its square to both sides of the equation. L.H.S of the equation was factorized in order to obtain the values of x, as seen below. One of the groups of students asks is this the procedure of evaluating this equation $x^2 - 3x + 2 = 0$ using completing the square method? Etc.

Equating the relation to the constant c, we have

$x^2 - 3x = -2$

Dividing both sides of the equation by 1

$x^2 + \frac{3}{1}x = \frac{2}{1}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

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

$(x + \frac{3}{2})^2 = \frac{2}{1} + \frac{9}{4}$

$x + \frac{3}{2} = \pm\sqrt{8 + 9}/4$

Expanding L.H.S of the equation we have

$x = -\frac{3}{2} \pm \sqrt{(17)}/4$

$x = -\frac{3}{2} \pm 1.03$

Either $x = -1.5 + 1.03$ or x = - 1.5- 1.03

Either, x = 0.47 or x = - 2.53

Presentation Rule 3: Researcher Response to Statement of Theories. The teacher refrained from evaluating the student's theories when they presented their theories. Researcher records the student's theories on the board or asks questions about the theories. Examples of the theories include, taking the constant c to the right hand side of the equation, ability to divide both sides of the equation by a, ability to doubled the coefficient of the denominator of x and add its square to both sides of the equation in order to find the values of x. Alternatively, Teacher ask the students are you to divide both sides of the equation by a?. Did you transfer the constant to the other sides of the equation? Are you supposed to take the square roots of both sides? Etc.

Presentation Rule 4: Testing Theories: The researcher ask the students to test their theories at any time i.e. the different factors they thought are the required factors, while the researcher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The researchers response was always, yes or no. That will help the students to know whether their formulated theories are correct or wrong. For example, a student test the theories by evaluating $x^2 - 8x + 4 = 0$ for values of x Using completing the square method. Equating the relation to the constant c, we have

$x^2 - 8x = -4$

Dividing both sides of the equation by 1

$x^2 + \frac{8}{1}x + \frac{8}{2} = = -4 + (\frac{8}{2})^2$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{8}{1}x + (\frac{8}{2})^2 = -4 + (\frac{8}{2})^2$

Expanding L.H.S of the equation we have

$(x + 4)^2 = -4 + (4)^2$

$x + 4 = \pm\sqrt{(-4 + 16)}$

$x = -4 + \sqrt{(12)}$ or $x = -4 - \sqrt{(12)}$

Either $x = -4 + 3.46$ or $x = -4 - 3.46$

Either, $x = -0.54$ or $x = -7.46$

Presentation Rule 5: Cooperation: The researcher observed the students and encouraged them to work as a team in order to confer and discuses their theories. The researcher gave four different problems to four different groups to make inquiries and demonstrate how each can be solved using completing the square method, and find the values of x.

Group A	Group B
$x^2 - 3x + 2 = 0$	$x^2 + 5x - 6 = 0$
Equating to the constant	equating to the constant
$x^2 - 3x = -2$	$x^2 + 5x = 6$
Dividing both sides by 1	dividing both sides by 1 then,
$x^2 - \frac{3}{1}x = -\frac{2}{1}$	$x^2 + \frac{5}{1}x = \frac{6}{1}$
Adding $(-\frac{3}{2})2$ to both sides	adding $(\frac{5}{2})2$ to both sides
$x^2 - \frac{1}{2}x + (-\frac{3}{2})2 = \frac{1}{2} + \left(\frac{3}{2}\right)2$	$x^2 + \frac{5}{1}x + (\frac{5}{2})2 = \frac{6}{1} + \left(\frac{5}{2}\right)2$
Factorizing L.H.S	Factorizing L.H.S then,
$(x - \frac{3}{2})^2 = \left(\frac{1}{2}\right)2 + (\frac{3}{2})2$	$(x + \frac{5}{2})^2 = \frac{6}{1} + \left(\frac{5}{2}\right)2$
Square root of both sides	taking square root of b. sides

$x - \frac{3}{2} = \pm\sqrt{(\frac{1}{4} + \frac{9}{4})}$ so that,

$x = \frac{3}{2} \pm\sqrt{(\frac{1+9}{4})}$ so that,

$x = \frac{3}{2} \pm\sqrt{(\frac{10}{4})}$

$x = 1 \pm \sqrt{(\frac{10}{4})}$

x = 1 + 1.56 or x = - 0.56

x = 2.56 or x = - 0.57

$x + \frac{5}{2} = \pm\sqrt{(\frac{6}{1} + \frac{25}{4})}$ so that,

$x = -\frac{5}{2} \pm \sqrt{(\frac{6}{1} + \frac{25}{4})}$ so that,

$x = -\frac{5}{2} \pm \sqrt{(\frac{24+25}{4})}$ so that,

$x = -\frac{5}{2} \pm \frac{7}{2}$

x = - 1 or x = - 6

x = = - 1 or x = - 6

<u>Group C</u>

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

Equating to the constant

$x^2 + 2x = 3$

Dividing both sides by 1

$x^2 - \frac{2}{1}x = \frac{3}{1}$

Adding $(-\frac{2}{2})2$ to both sides

$x^2 - \frac{2}{1}x + (-\frac{2}{2})2 = \frac{3}{1} \pm \left(\frac{2}{2}\right)2$

Factorizing L.H.S

$(x - 1)^2 = \frac{3}{1} \pm (1)$

Taking square root of B.S

$x = 1 \pm \sqrt{(\frac{3}{1} + 1)}$ so that,

$x = \frac{1}{2} \pm\sqrt{(\frac{1+3}{1})}$ so that,

<u>Group D</u>

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

equating to the constant then,

$x^2 + 5x = 6$

dividing both sides by 1 then,

$x^2 + \frac{5}{1}x = \frac{6}{1}$

adding $(-\frac{5}{2})2$ to both sides

$x^2 + \frac{5}{1}x + (\frac{5}{2}) = \frac{10}{1} + \left(\frac{5}{2}\right)2$

Factorizing L.H.S then,

$(x + \frac{5}{2})^2 = \frac{10}{1} + \left(\frac{5}{2}\right)2$

taking square root of

$x += -\frac{5}{2} \pm \sqrt{(\frac{10}{1} + \frac{25}{4})}$

$x = -\frac{5}{2} \pm \sqrt{(\frac{40+25}{4})}$ so that,

$x = \frac{1}{2} \pm \sqrt{(\frac{4}{1})}$ $x = -\frac{5}{2} \pm \sqrt{(\frac{65}{4})}$ so that,

$x = \frac{1}{2} + 2$ or $x = \frac{1}{2} - 2$ $x = -2.5 \pm 4.03$

x = 2.5 or x = -1.5 x = 1.53 or x = -6.53

Presentation Rule 6: Experimenting: The researcher provide materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The researcher evaluates the lesson by asking the students to find the values of the following quadratic equation using completing the square method.

(i) $2x^2$-+3x - 5 = 0 (ii) x^2 - 4x - 5 = 0 (iii) x^2 - 7x - 8 = 0

Conclusion: The researcher concluded the lesson by going round to observe what the students have done after making all inquiries.

LESSON 6

Class: SSSII

Time: 2Hours

Subject Area: Quadratic Equation

Topic: Solutions of Quadratic Equations Using Quadratic Formula.

Instructional Material: New General Mathematics for Senior Secondary Schools book 2

Behavioral Objectives: By the end of the Lesson, students should be able to find the solutions of quadratic equation using quadratic formula.

Previous Knowledge: Students have been able to use the general quadratic equation using completing the square method to derive the quadratic formula i.e $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$ the relation is derived from $ax^2 + bx + c = 0$, as follows.

Equating the relation to the constant c, we have

$x^2 + bx = -c$

Dividing both sides of the equation by a

$x^2 + \frac{b}{a}x = -\frac{c}{a}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{b}{a}x + (\frac{b}{2a})\,2 = -\frac{c}{a} + (\frac{b}{2a})^2$

$(x + \frac{b}{a})^2 = \frac{b2}{4a2} - \frac{c}{a}$

$x + \frac{b}{a} = \pm\sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

Expanding L.H.S of the equation we have

$x = -\frac{b}{a} \pm \sqrt{(\frac{b2}{4a2} - \frac{c}{a})}$

$x = -\frac{b}{a} \pm \sqrt{\frac{b2-4ac}{4a2}}$

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

Either, x = $x = \frac{-b+\sqrt{b^2-4ac}}{2a}$ or x = $x = \frac{-b-\sqrt{b^2-4ac}}{2a}$

Introduction Rule A: The researcher introduced the lesson by engaging the students in an exploration of problem staged through inquiry-demonstration and by the used of prepared questions in quadratic equation. The major portion of the inquiry-demonstration session is devoted to the students, asking questions in order to gather enough data which they will use to formulate their theories i.e. to evaluate the equation using completing the squares method we need to follow the same procedure applied in the previous knowledge. Some of the problems include:

(a) $x^2 + 2x – 8 = 0$ (b) $x^2 + x – 6 = 0$ (c) $2x^2 + x - 3 = 0$

Presentation Rule 1: Questioning: The researcher instructs the students to formulate questions and the questions are phrased in such a way that they can be answered yes or no, So that the burden of thinking will be shifted to the students. The teacher expects them to come up with an idea based on the previous knowledge of completing the square method of the general quadratic equation. Thus, $ax^2 + bx + c = 0$.

Presentation Rule2: Freedom to ask questions: The researcher allowed the students to ask as many questions as possible once they stated. This is to encourage the students to use his or her previous questions to formulate new ones in order to pursue a reasonable theory. The climate of the classroom must be made in order to poster the axiom "that there are no dumb questions". The researcher resisted all questions raised by the students. The normal procedure of dividing both sides of the equation by the coefficient of x^2 was maintained. Then doubling the denominator of the coefficient of x and adding its square to both sides of the equation. Left hand side of the equation was factorized in order to obtain the values of x, as seen below. One of the groups

of students asks, Is it the procedure of evaluating this quadratic equation $x^2 + 2x - 8 = 0$ using the general formula?

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

Comparing the coefficients of x^2, x and c with $ax^2 + bx + c$, thus,

a = 1, b = 2 and c = - 8.

Substituting the values in the equation we have

$x = \frac{-1 \pm \sqrt{2^2 - 4 \text{ x } 1 \text{ x} -8}}{2 \, x \, 1}$

$x = \frac{-2 \pm \sqrt{(4 + 32)}}{2}$

$x = \frac{-2 \pm \sqrt{36}}{2}$

$x = \frac{-2 \pm 6}{2}$

Either, $x = -\frac{2+6}{2}$ or $x = -\frac{2-6}{2}$

$x = \frac{4}{2}$ or $x = -\frac{8}{2}$

x = 2 or x = -4

Presentation Rule 3: Researcher Response to Statement of Theories. The researcher refrained from evaluating student's formulated theories. Teacher records the student's theories on the board or ask questions about the theories. Examples of the theories set by the students include, can I compare the coefficients of a, b, and c with the given equation in order to substitute the values in the general formula? The researcher asked is that how you will compare the coefficients of the variables? Etc.

Presentation Rule 4: Testing Theories: The researcher ask the students to test their theories at any time in order to know the required coefficients, while

the researcher is watching. The students work as a team and are allowed to inquire and demonstrate in order to arrive at a workable theories. The teacher's response is always, yes or no. That will help the students to know whether their formulated theories are correct or wrong. For example, a student tests the theories by evaluating $2x^2 + x - 3 = 0$ for values of x the general formula.

Comparing the variables with the coefficient of the given equation

Thus, and substituting the values in the general formula,

a = 2, b = 1 and c = - 3

$$x = - \frac{b \pm \sqrt{(b2 - 4ac)}}{2a}$$

$$x = \frac{-1 \pm \sqrt{(1 - 4\ x\ 1\ x - 3)}}{2\ x\ 2}$$

$$x = \frac{-1 \pm \sqrt{(1+12)}}{4}$$

$$x = - \frac{1 \pm \sqrt{(13)}}{4}$$

$$x = - \frac{1 \pm 3.6}{4}$$

Either, $x = - \frac{1 + 3.6}{4}$ or $x = \frac{-1 - 3.6}{4}$

$x = \frac{2.6}{4}$ or $x = \frac{-4.6}{4}$

x = 0.65 or x = - 4.15

Presentation Rule 5: Cooperation: The researcher observed the students and encouraged them to work as a team in order to confer and discuses their theories. The researcher gave four different problems to four different groups to make inquiries and demonstrations on how each can be used to formulate new theories, in order to find the values of x using quadratic formula

Group A

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

Comparing coefficients

a = 2, b = 1 and c = - 3

Subt. the values in the eqn.

$x = \frac{-1 \pm \sqrt{-1^2 - 4 \text{ x } 2 \text{ x} -3}}{2 \, x \, 2}$

$x = 1 \pm \sqrt{\frac{1+12}{4}}$

$x = \frac{1 \pm \sqrt{13}}{4}$

Either, $x = \frac{1 + 3.61}{4}$ or $x = \frac{1-3.61}{4}$

x = 1.15 or x = - 0.65

Group B

$x^2 + x - 6 = 0$

comparing coefficients

a = 1, b = 1 and c = - 6

Subst. the values then equation

$x = \frac{-1 \pm \sqrt{1^2 - 4 \text{ x } 1 \text{ x} -6}}{2 \, x \, 1}$

$x = \frac{-1 \pm \sqrt{1+24}}{2}$

$x = \frac{-1 \pm \sqrt{25}}{2}$

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

either, x = 2 or x = - 3

Group C

$4x^2 + 4x - 3 = 0$

Comparing coefficients

a = 4, b = 4 and c = -3

Subst. the values in the eqn

$x = \frac{-4 \pm \sqrt{4^2 - 4 \text{ x } 4 \text{ x} -3}}{2 \, x \, 4}$

$x = -4 \pm \sqrt{\frac{16+48}{8}}$

$x = \frac{16 \pm \sqrt{65}}{8}$

Either, $x = \frac{16 + 8.06}{8}$ or $x = \frac{16-8.06}{8}$

Group D

$x^2 + 7x - 10 = 0$

comparing coefficients

a = 1, b = 7 and c = -10

Subst. the values then equation

$x = \frac{-7 \pm \sqrt{7^2 - 4 \text{ x } 1 \text{ x} - 10}}{2 \, x \, 1}$

$x = \frac{-7 \pm \sqrt{49+40}}{4}$

$x = \frac{-7 \pm \sqrt{89}}{4}$

$x = \frac{-7+9.43}{4}$ or $x \frac{-7-9.43}{4}$

$x = \frac{25.06}{8}$ or $x = -\frac{7.06}{8}$ either, $x = -\frac{2.43}{4}$ or $x = -\frac{16.43}{4}$

$x = 3.13$ or $x = 0.8$ $x = -0.61$ or $x = -4.11$

Presentation Rule 6: Experimenting: The researcher provide materials from texts and other reference books so that the students can explore their ideas

Presentation Rule H: Evaluation: The researcher evaluates the lesson by asking the students to find the values of the following quadratic equation using quadratic formula

(i) $3x^2 + 6x + 3 = 0$ (ii) $x^2 - x - 6 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion: The researcher conclude the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories which are then used to evaluate for using quadratic formula.

APPENDIX B

LESSON PLAN FOR

CONTROL GROUP

(USING NORMAL CLASSROOM SETTING)

LESSON 6

Class: SSSII

Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using Factorization Method
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives:	By the end of the Lesson, students should be able to factorize quadratic equations using factorization method.
Previous Knowledge:	Students have been able to use completing the square method to find the values of x
Introduction:	The researcher introduced the lesson by asking the students to find the values of the following quadratic equations using factorization method?

(a) $x^2 + 2x - 8 = 0$ (b) $x^2 + x - 6 = 0$ (c) $2x^2 + 5x + 3$

Presentation Step ii: The researcher presents the lesson by explaining to the students with examples on how to find the values of the following quadratic equations using factorization method.

Eg1. Factorize $x^2 + 8x + 15 = 0$

Step ii: The researcher explained to the students that since the equation involves the use of factors then, to obtain the factors we multiply x^2 by 15 to get $15x^2$. The various factors of $15x^2$ are, x and 15x, -x and -15x, 3x and 5x, -3x and -5x. The required factor is 3x and 5x, and sum of the factors gives 8x, which is the middle number of the given equation. Thus,

$x^2 + 8x + 15 = 0$

Substituting 8x with the required factors 3x and 5x to get

$x^2 + 3x + 5x + 15 = 0$

Factorizing the L.H.S of the equation to get

$x(x + 3) + 5(x + 3) = 0$

Step iii the teacher woks one or two examples with the students.

` (a) $2x^2 – x – 1 = 0$

(b) $x^2 + x – 2 = 0$

Evaluation: The researcher evaluates the lesson by asking the students to solve the following quadratic equations using factorization method.

(a) $3x^2 - 8x - 3 = 0$

(b) $2x^2 - 3x - 3 =0$

(c) $x^2 – 6x + 8 =0$

Conclusion: The researcher concludes the lesson by going round to see the students as they solve the problem and assists them where necessary

LESSON 7

Group:	Control (lecture method)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using completing the Square Method
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Previous Knowledge:	Students have been able to use completing the square method to find the solutions of the quadratic equation.
Introduction:	The researcher introduced the lesson by asking the students to find the values of x in each of the following quadratic equation.

(a) $x^2 + 2x - 8 = 0$ (b) $x^2 + x - 6 = 0$ (c) $2x^2 + 5x + 3 = 0$

Presentation Step i: The researcher presents the lesson by explaining to the students with examples on how to find the values of the following quadratic equations using completing the square method.

Eg1. Use completing the square method to find the values of x in the equation $x^2 + 8x + 15 = 0$.

Step ii: he teacher explain to the students that the first step is to clear the coefficient of x2 and equate the constant 15 to the other side then,

$x^2 + 8x + 15 = 0$

$x^2 + 8x = -15$

Dividing both sides of the equation by 1

$x^2 + \frac{8}{1}x = -\frac{15}{1}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{8}{1}x + (\frac{8}{2})^2 = -\frac{15}{1} + (\frac{8}{2})^2$

Expanding L.H.S of the equation we have

$(x + 4)^2 = -\frac{15}{1} + (4)^2$

$x + 4 = \pm\sqrt{(-15 + 16)}$

$x = -1 \pm \sqrt{(1)}$

$x = -1 \pm 1$

Either $x = -1 + 1$ or x = -1 - 1

Either, x = 0 or $x = -2$

Step iii: The teacher woks one or two examples with the students.

(a) $2x^2 - x - 1 = 0$

(b) $x^2 + x - 2 = 0$

Evaluation: The researcher evaluates the lesson by asking the students to solve the following quadratic equations using completing the square method.

(a) $3x^2 - 8x - 3 = 0$
(b) $2x^2 - 3x - 3 = 0$
(c) $x^2 - 6x + 8 = 0$

Conclusion: The researcher concludes the lesson by going round to see the students as they solve the problem and assists them where necessary.

LESSON 8

Group:	Control (Lecture Method)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations Using Quadratic Formula.
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives:	By the end of the Lesson, students should be able to find the solutions of quadratic equation using quadratic formula.
Previous Knowledge:	Students have been able to use the general quadratic formula i.e. $= \frac{-b \pm \sqrt{b^2-4ac}}{2a}$, to find the values of a given quadratic equation $ax^2 + bx + c = 0$,
Introduction:	The researcher introduced the lesson by asking the students to find the values of x in the following quadratic equations using quadratic formula. (a) $x^2+2x - 8 = 0$ (b) $x^2 + x - 6 = 0$ (c) $2x^2 + 5x+3 = 0$
Presentation Step i:	The researcher presents the lesson by explaining to the students with example how to find the values of x in a given quadratic equation using quadratic formula. E.g. Use quadratic formula to find the values of x in the equation $x^2 + 8x +15 = 0$
Step ii :	The researcher explain to the students that the coefficients of the given equation would have to be compared with the coefficients

of the general quadratic equation thus, $x^2 + 8x + 15 = 0$ Comparing the coefficient of the given equation with the quadratic equation, $ax^2 + bx + c = 0$ a = 1, b = 8 and c =15. Substituting the values in the general formula, we get

$$x = - \frac{b \pm \sqrt{(b2 - 4ac)}}{2a}$$

$$x = \frac{-1 \pm \sqrt{(82 - 4\ x\ 1\ x\ 15)}}{2\ x\ 1}$$

$$x = \frac{-1 \pm \sqrt{(82-60)}}{2} \quad x = - \frac{1 \pm \sqrt{(22)}}{2} \quad x = - \frac{1 \pm 4.69}{2}$$

Either, $x = - \frac{1 + 4.69}{2}$ or $x = \frac{-1 - 4.69}{2}$

Either, $x = \frac{3.69}{2}$ or $x = \frac{-5.69}{2}$

x = 1.845 or x = -2. 845

Presentation Step iii: The researcher works one or two examples with the students.

(a) $2x^2 - x - 1 = 0$

(b) $x^2 + x - 2 = 0$

Evaluation: The researcher evaluates the lesson by asking the students to find the values of the following quadratic equations using quadratic formula

(a) $3x^2 + 4x + 3 =$ (b) $2x^2 - 3x - 5 = 0$

(c) $x^2 - 6x + 8 = 0$

Conclusion: The researcher concludes the lesson by going round to see the students as they solve the problem and assists them where necessary.

LESSON 9

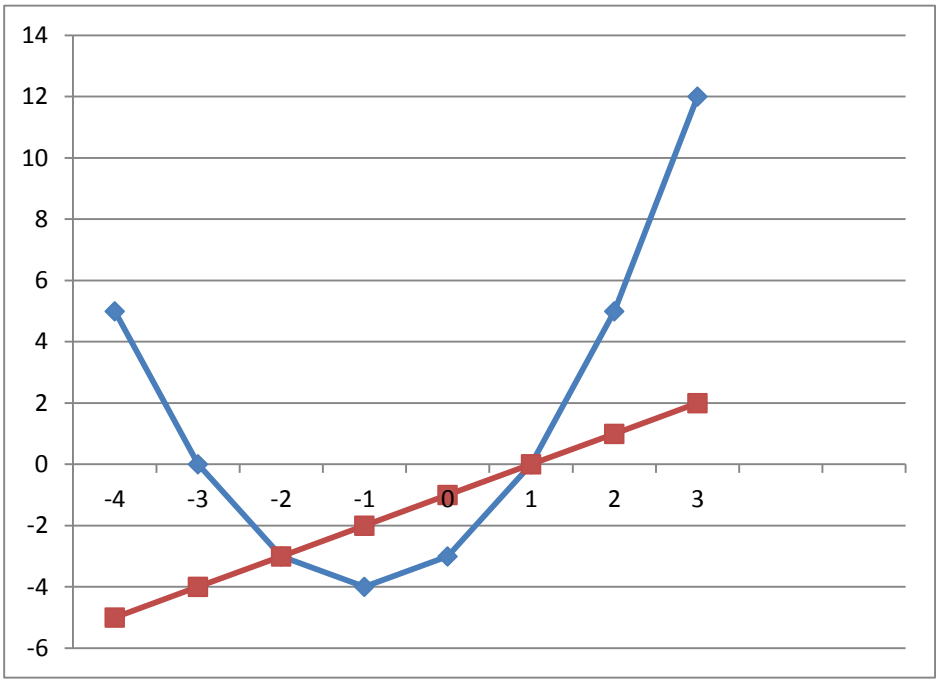
Group**:**	Experimental (Inquiry-Demonstration)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using Graphical Method
Instructional Material**:**	New General Mathematics for Senior Secondary Schools book, a graph board, chalk board
Behavioral Objectives**:**	By the end of the Lesson, students should be able to draw a quadratic graph using graph sheet.
Previous Knowledge**:**	Students have been able to draw a linear or straight line graph
	E.g. Students were asked to plot the graph of $y = x^2 + 2x - 3$ each for which values of x between -4 to +3 was indicated in inequality form $-4 \leq x \leq 3$. using a scale of 1cm to I unit on both axes. Using the same scale and axes plot the graph of $y = x - 1$. Find the points of intersection of the two the curve and the straight line. Students have two methods i.e. by either substituting each value of x directly in the equation or putting the values on a table and find the values of each number of the given quadratic equation. For the purpose of celerity and shortest possible way of calculating the corresponding values of y table of values was used.

$y = x^2 + 2x - 3$ and the domain of x are $-4 \leq x \leq 3$

Scale: 1cm to 1unit on box axes

X	-4	-3	-2	-1	0	1	2	3
X^2	16	9	4	1	0	1	4	9
2x	-8	-6	-4	-2	0	2	4	6
-3	-3	-3	-3	-3	-3	-3	-3	-3
Y_1	**5**	**0**	**-3**	**-4**	**-3**	**0**	**5**	**12**

X	-4	-3	-2	-1	0	1	2	3
-1	-1	-1	-1	-1	-1	-1	-1	-1
Y_2	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**



(i) $x^2 + 5x + 6 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion:	The researcher concludes the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories or factors. The factors are then used to factorize the equations

LESSON 10

Group:	Control (lecture method)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using completing the Square Method
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Previous Knowledge:	Students have been able to use completing the square method to find the solutions of the quadratic equation.
Introduction:	The researcher introduced the lesson by asking the students to find the values of x in each of the following quadratic equation.

(a) $2x^2 + 2x – 4 = 0$ (b) $x^2 + x – 6 = 0$ (c) $2x^2 + x - 3 = 0$

Presentation Step i: The researcher presents the lesson by explaining to the students with examples on how to find the values of the following quadratic equations using completing the square method.

Eg1. Use completing the square method to find the values of x in the equation $2x^2 + 2x - 4 = 0$.

Step ii: The researcher explain to the students that the first step is to clear the coefficient of x^2 and equate the constant 4 to the other side then,

Dividing both sides of the equation by 1

$x^2 + \frac{2}{1}x = \frac{4}{1}$

Doubled the denominator of the coefficient of x and add its square to both sides of the equation

$x^2 + \frac{2}{1}x + \left(\frac{2}{2}\right)2 = \frac{4}{1} + (\frac{2}{2})2$

Expanding L.H.S of the equation we have

$(x + 1)^2 = 4 + (1)2$

$x + 1 = \pm\sqrt{(4 + 1)}$

$x = -1 \pm\sqrt{(4 + 1)}$

$x = -1 \pm\sqrt{(5)}$

$x = -1 \pm 2.24$

Either $x = -1 + 2.24$ or $x = -1 - 2.24$

Either, $x = 1{,}24$ or $x = -3.24$

Step iii: The researcher woks one or two examples with the students.

(c) $x^2 - x - 6 = 0$

(d) $x^2 + x - 2 = 0$

Evaluation: The researcher evaluates the lesson by asking the students to solve the following quadratic equations using completing the square method.

(d) $x^2 - 5x - 8 = 0$
(e) $2x^2 - 3x - 3 = 0$
(f) $x^2 + 2x + 8 = 0$

Conclusion: The researcher concludes the lesson by going round to see the students as they solve the problem and assists them where necessary.

LESSON 11

(USING NORMAL CLASSROOM SETTING)

Group:	Control (Lecture Method)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations Using Quadratic Formula.
Instructional Material:	New General Mathematics for Senior Secondary Schools book 2
Behavioral Objectives:	By the end of the Lesson, students should be able to find the solutions of quadratic equation using quadratic formula.
Previous Knowledge:	Students have been able to use the general quadratic formula i.e. $= \frac{-b \pm \sqrt{b^2-4ac}}{2a}$, to find the values of a given quadratic equation $ax^2 + bx + c = 0$,
Introduction:	The researcher introduced the lesson by asking the students to find the values of x in the following quadratic equations using quadratic formula. (a) $2x^2+8x + 8 = 0$ (b) $x^2 + x – 6 = 0$ (c) $x^2 + 5x+6 = 0$
Presentation Step i:	The researcher presents the lesson by explaining to the students with example how to find the values of x in a given quadratic equation using quadratic formula. E.g. Use quadratic formula to find the values of x in the equation $x^2 + x - 6 = 0$

Step ii : The researcher explain to the students that the coefficients of the given equation would have to be compared with the coefficients of the general quadratic equation thus, $x^2 + x - 6 = 0$ Comparing the coefficient of the given equation with the quadratic equation, $ax^2 + bx + c = 0$ a = 1, b = 1 and c = - 6. Substituting the values in the general formula, we get

$$x = - \frac{b \pm \sqrt{(b2 - 4ac)}}{2a}$$

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

$$x = \frac{-1 \pm \sqrt{(25)}}{2} \quad x = - \frac{1 \pm 5}{2} \quad x = - \frac{1 \pm 5}{2}$$

Either, $x = - \frac{1 + 5}{2}$ or $x = \frac{-1 - 5}{2}$

Either, $x = \frac{4}{2}$ or $x = \frac{-4}{2}$

x = 2 or x = -2

Presentation Step iii: The researcher works one or two examples with the students.

(b) $x^2 - 4x - 5 = 0$

(b) $x^2 + x - 2 = 0$

Evaluation: The researcher evaluates the lesson by asking the students to find the values of the following quadratic equations using quadratic formula

(b) $x^2 + 4x + 3 = 0$ (b) $2x^2 + 7x + 5 = 0$

(c) $x^2 - 6x + 8 = 0$

Conclusion: The researcher concludes the lesson by going round to see the students as they solve the problem and assists them where necessary.

LESSON 12

Group**:**	Experimental (Inquiry-Demonstration)
Class:	SSSII
Time:	2Hours
Subject Area:	Quadratic Equation
Topic:	Solutions of Quadratic Equations using Graphical Method
Instructional Material**:**	New General Mathematics for Senior Secondary Schools book, a graph board, chalk board
Behavioral Objectives**:**	By the end of the Lesson, students should be able to draw a quadratic graph using graph sheet.
Previous Knowledge**:**	Students have been able to draw a linear or straight line graph

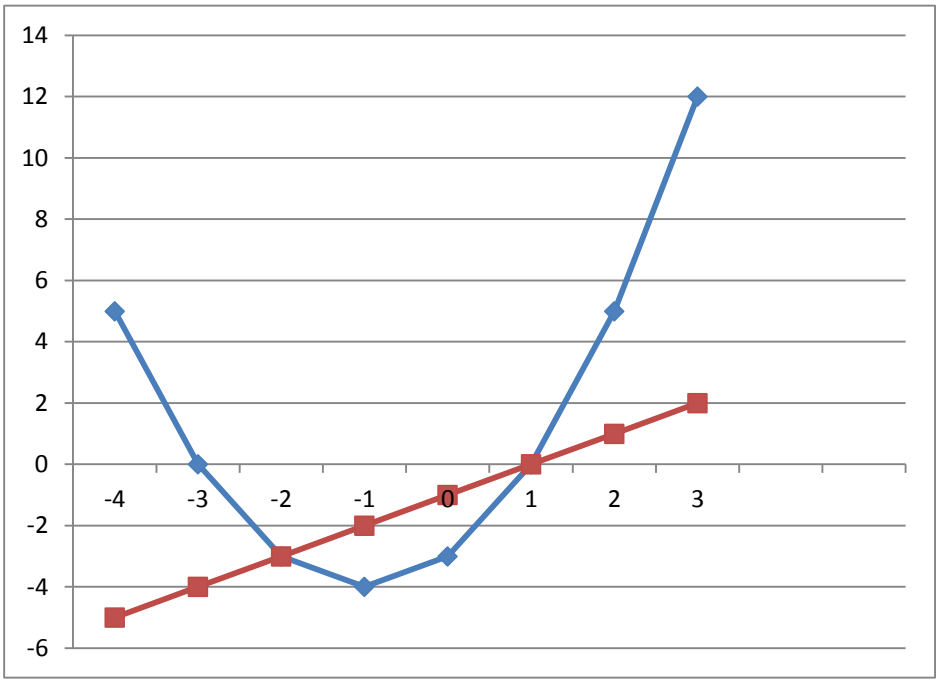
E.g. Students were asked to plot the graph of $y = x^2 + 2x - 3$ each for which values of x between -4 to +3 was indicated in inequality form $-4 \leq x \leq 3$. using a scale of 1cm to I unit on both axes. Using the same scale and axes plot the graph of $y = x - 1$. Find the points of intersection of the two the curve and the straight line. Students have two methods i.e. by either substituting each value of x directly in the equation or putting the values on a table and find the values of each number of the given quadratic equation. For the purpose of celerity and shortest possible way of calculating the corresponding values of y table of values was used.

$y = x^2 + 2x - 3$ and the domain of x are $-4 \leq x \leq 3$

Scale: 1cm to 1unit on box axes

X	-4	-3	-2	-1	0	1	2	3
X^2	16	9	4	1	0	1	4	9
2x	-8	-6	-4	-2	0	2	4	6
-3	-3	-3	-3	-3	-3	-3	-3	-3
Y_1	**5**	**0**	**-3**	**-4**	**-3**	**0**	**5**	**12**

X	-4	-3	-2	-1	0	1	2	3
-1	-1	-1	-1	-1	-1	-1	-1	-1
Y_2	**-5**	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**



(i) $x^2 + 5x + 6 = 0$ (ii) $2x^2 - 3x - 5 = 0$ (iii) $x^2 - 6x + 8 = 0$

Conclusion:	The researcher concludes the lesson by going round to observe what the students have done after making all necessary inquiries and demonstrations on how they have obtained their theories or factors. The factors are then used to factorize the equations

APPENDIX C

NEWMAN ERROR TEST ITEMS

(EXPERIMENTAL AND CONTROL GROUPS)

INSTRUCTION: Answer all questions from the four sections (A, B, C and D) on the answer sheets provided. Each question carries marks.

TIME ALLOWED: 2 Hours.

SECTION A

Use factorization method to find the values of the following quadratic equations

1. $x^2 + 2x – 8 = 0$ 2. $x^2 + x – 6 = 0$

SECTION B

Use completing the square method to find the values of the following quadratic equations

2. $x^2 + 8x + 15 = 0$ 4. $x^2 – x – 1 = 0$

SECTION C

Use quadratic formula method to find the values of x in the following quadratic equations

5. $3x^2 - 8x -3 = 0,$ 6. $2x^2 - 3x - 5 = 0$

SECTION D

Use a scale of 1cm to 2 units on x and y axes to plot the graphs of the following quadratic equations. Hence determine the roots of the equations.

5. $x^2 + x – 2 = 0$ 8. $2x^2 +5x + 3 = 0$

PERFORMANCE TEST ANSWERS FOR

(EXPERIMENTAL GROUP)

SECTION A

1. $x^2 + 2x – 8 = 0$

   Multiplying x^2 by -8 to get $-8x^2$

   The factors of $-8x^2$ are -2x and 4x, -4x and x, x and 8x

   The required factor is -2x and 4x

   Replacing 2x with -2x + 4x as the factors

   $x^2 – 2x + 4x - 8 = 0$

   Factorizing the L.H.S of the equation

   $x(x - 2) + 4(x-2) = 0$

   Re- factorizing again

   $(x - 2) (x + 4) = 0$

   Either, $x - 2 = 0$ or $x + 4 = 0$

   Either, $x = 2$ or $x = -4$ (7 ½ marks)

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

   Multiplying x^2 by $-6 = -6x^2$

   The factors of $-6x^2$ are -2x and 3x

   $x^2 – 2x + 3x - 6 = 0$

   Factorizing L.H.S of the equation we get

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

   Factorizing again we have

   $(x – 2) (x + 3) = 0$

   Either, $x – 2 = 0$ or $x + 3 = 0$ (7 ½ marks)

   Either, $\underline{x = 2}$ or $\underline{x = -3}$

3. $2x^2 + 5x + 3 = 0$

   Multiplying 2x and 3 to get $6x^2$

   The required factor is 2x and 3x

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

Factorizing L.H.S we get

$2x(x + 1) + 3(x + 1)$

Re- factorizing we get

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

Either, $x + 1 = 0$ or $2x + 3 = 0$ (7 ½ marks)

Either, $x = -1$ or $x = -3/2$

SECTION B

4. $x^2 + 8x + 15 = 0$

Equating to constant 15

$x^2 + 8x = -15$

Dividing both sides by 1 the coefficient of x^2

$x^2 + \frac{8}{1}x = -\frac{15}{1}$

Doubling the denominator of the coefficient of x and add the square of the coefficient to both sides of the equation.

$x^2 + \frac{8}{1}x + (\frac{8}{2})^2 = -\frac{15}{1} + (\frac{8}{2})^2$

Factorizing L.H.S of the equation we get

$(x + \frac{8}{2})^2 = -15 + (\frac{8}{2})^2$

$(x + 4)^2 = -15 + 4^2$

$(x + 4)^2 = -15 + 16$

Taking the square root of both sides we get

$x + 4 = \pm\sqrt{1}$

$X = -4 \pm \sqrt{1}$

$x = -4 \pm 1$

Either, $x = -4 + 1$ or $x = -4 - 1$ (7 ½ marks)

Either, $x = -3$ or $x = -5$

5. $2x^2 – x -1 = 0$

Equating to constant 1

$2x^2 – x = 1$

Dividing both sides of the equation by 2 we get

$x^2 - \frac{1}{2}x = \frac{1}{2}$

Doubling the denominator of the coefficient of x and adding the square of the coefficient to both sides we get

$x^2 - \frac{1}{2}x + (-\frac{1}{4})^2 = \frac{1}{2} + \left(-\frac{1}{4}\right)^2$

Factorizing L.H.S we get

$(x - \frac{1}{4})^2 = \frac{1}{2} + (-\frac{1}{4})^2$

$(x - \frac{1}{4})^2 = \frac{1}{2} + \frac{1}{16}$

Taking the square root of both sides we get

$(x - \frac{1}{4}) = \pm\sqrt{(\frac{8+1}{16})}$

$x - \frac{1}{4} = \pm\sqrt{(\frac{9}{16})}$

$x = \frac{1}{4} \pm \frac{3}{4}$

Either, $x = \frac{1}{4} + \frac{3}{4}$ or $x = \frac{1}{4} - \frac{3}{4}$

Either, $x = \frac{4}{4}$ or $x = -\frac{2}{4}$

$x = 1$ or $x = -\frac{1}{2}$ (7 ½ marks)

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

Equating to constant

$x^2 + x = 2$

Dividing both sides by the coefficient of x^2 which is 1 we get

$x^2 + \frac{1}{1}x = \frac{2}{1}$

Doubling the denominator of the coefficient of x and adding the square of the coefficient to both sides of the equation we get

$x^2 + \frac{1}{1}x + (\frac{1}{2})^2 = \frac{2}{1} + (\frac{1}{2})^2$

Factorizing L.H.S of the equation we get

$\left(x + \frac{1}{2}\right) = \pm\sqrt{(2 + \frac{1}{4})}$

$x + \frac{1}{2} = \pm\sqrt{(\frac{8+1}{4})}$

$X = -\frac{1}{2} \pm \sqrt{(\frac{9}{4})}$

Either, $x = -\frac{1}{2} + \frac{3}{2}$ or $x = -\frac{1}{2} - \frac{3}{2}$

Either, $x = \frac{2}{2}$ or $x = -\frac{4}{2}$

Either, x = 1or x = -2 (7 ½ marks)

SECTION C

7. $3x^2 - 8x - 3 = 0$

Comparing coefficients

a = 3, b = -8 and c = -3

Substituting the values in the formula we get

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

$x = \frac{--8 \pm \sqrt{(-8^2)\ x\ -4\ x\ 3 - 3}}{2\ x\ 3}$

$x = \frac{8 \pm \sqrt{64+36}}{6}$

$x = \frac{8 \pm \sqrt{100}}{6}$

$x = \frac{8 \pm 10}{6}$

Either, $x = \frac{8+10}{6}$ or $x = \frac{8-10}{6}$

Either, $x = \frac{18}{6}$ or $x = \frac{-2}{6}$ either, $x = 3$ or $x = -\frac{1}{3}$ (7 ½ marks)

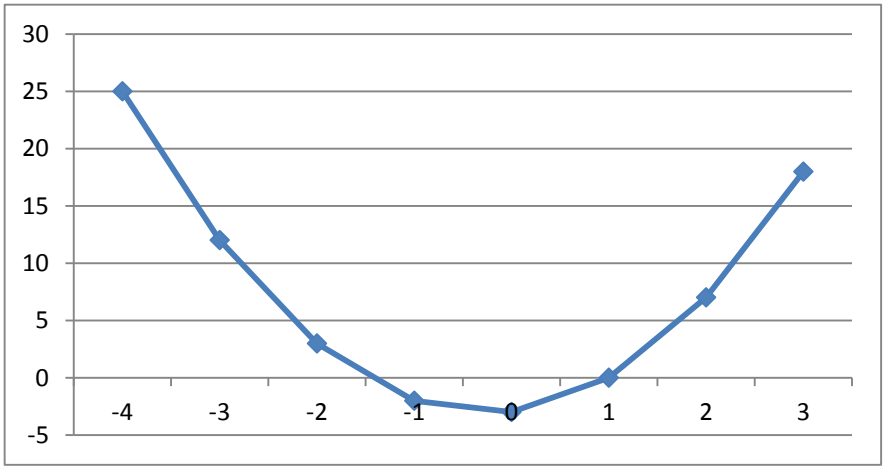
8. $2x^2 + x - 3 = 0$

Using substitution method for each value of x to find the corresponding value of y

$y = 2x^2 + x - 3$ and the domain of x are $-4 \leq x \leq 3$

Scale: 1cm to 1unit on x axis and 1cm to 2units on y axis

X	-4	-3	-2	-1	0	1	2	3
$2x^2$	32	18	8	2	0	2	8	18
X	-4	-3	-2	-1	0	2	2	3
-3	-3	-3	-3	-3	-3	-3	-3	-3
Y_1	**25**	**12**	**3**	**-2**	**-3**	**1**	**7**	**18**



(7 ½ marks)

PERFORMANCE TEST ANSWERS FOR

(CONTROL GROUP)

SECTION A

1. $X^2 + 2x – 8 = 0$

   Multiplying x^2 by -8 to get $-8x^2$

   The factors of $-8x^2$ are -2x and 4x, -4x and x, x and 8x

   The required factor is -2x and 4x

   Replacing 2x with -2x + 4x as the factors

   x^2 2x + 4x -8 = 0

   Factorizing the L.H.S of the equation

   x(x -2) + 4(x-2) = 0

   Re- factorizing again

   (x -2) (x + 4) = 0

   Either, x -2 = 0 or x + 4 = 0

   Either, x = 2 or x = -4 (7 ½ marks)

2. x^2 + x -6 = 0

   Multiplying x^2 by -6 = $-6x^2$

   The factors of $-6x^2$ are -2x and 3x

   x^2 – 2x + 3x -6 = 0

   Factorizing L.H.S of the equation we get

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

   Factorizing again we have

   (x – 2) (x + 3) = 0

   Either, x – 2 = 0 or x + 3 = 0

   Either, x = 2 or x = -3 (7 ½ marks)

3. $2x^2$ + 5x + 3 = 0

   Multiplying 2x and 3 to get $6x^2$

   The required factor is 2x and 3x

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

   Factorizing L.H.S we get

   2x(x + 1) + 3(x + 1)

Re- factorizing we get

(x + 1) (2x + 3) = 0

Either, x + 1 = 0 or 2x + 3 = 0, Either, X = -1 or x = - 3/2 (7 ½ marks)

SECTION B

4. x+ 8x + 15 = 0

Equating to constant 15

$X^2 + 8x = -15$

Dividing both sides by 1 the coefficient of x^2

$x^2 + \frac{8}{1} x = -\frac{15}{1}$

Doubling the denominator of the coefficient of x and add the square of the coefficient to both sides of the equation.

$x^2 + \frac{8}{1}x + (\frac{8}{2})^2 = -\frac{15}{1} + (\frac{8}{2})^2$

Factorizing L.H.S of the equation we get

$(x + \frac{8}{2})^2 = -15 + (\frac{8}{2})^2$

$(x + 4)^2 = -15 + 4^2$

$(x + 4)^2 = -15 + 16$

Taking the square root of both sides we get

$x + 4 = \pm\sqrt{1}$

$x = -4 \pm \sqrt{1}$

$x = -4 \pm 1$

Either, x = -4 +1 or x = -4 – 1

Either, x = -3 or x = -5 (7 ½ marks)

$2x^2 – x -1 = 0$

Equating to constant 1

$2x^2 –x = 1$

Dividing both sides of the equation by 2 we get

$x^2 - \frac{1}{2}x = \frac{1}{2}$

Doubling the denominator of the coefficient of x and adding the square of the coefficient to both sides we get

$x^2 - \frac{1}{2}x + (-\frac{1}{4})^2 = \frac{1}{2} + \left(-\frac{1}{4}\right)^2$

Factorizing L.H.S we get

$(x - \frac{1}{4})^2 = \frac{1}{2} + (-\frac{1}{4})^2$

$(x - \frac{1}{4})^2 = \frac{1}{2} + \frac{1}{16}$

Taking the square root of both sides we get

$(x - \frac{1}{4}) = \pm\sqrt{(\frac{8+1}{16})}$

$X- \frac{1}{4} = \pm\sqrt{(\frac{9}{16})}$

$x = \frac{1}{4} \pm \frac{3}{4}$

Either, $x = \frac{1}{4} + \frac{3}{4}$ or $x = \frac{1}{4} - \frac{3}{4}$

Either, $x = \frac{4}{4}$ or $x = -\frac{2}{4}$

$X = 1$ or $x = -\frac{1}{-2}$ (7 ½ marks)

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

Equating to constant

$x^2 + x = 2$

Dividing both sides by the coefficient of x^2 which is 1 we get

$x^2 + \frac{1}{1}x = \frac{2}{1}$

Doubling the denominator of the coefficient of x and adding the square of the coefficient to both sides of the equation we get

$x^2 + \frac{1}{1}x + (\frac{1}{2})^2 = \frac{2}{1} + (\frac{1}{2})^2$

Factorizing L.H.S of the equation we get

$\left(x + \frac{1}{2}\right) = \pm\sqrt{}(2 + \frac{1}{4})$, $x + \frac{1}{2} = \pm\sqrt{}(\frac{8+1}{4})$, $x = -\frac{1}{2} \pm \sqrt{}(\frac{9}{4})$

Either, $x = -\frac{1}{2} + \frac{3}{2}$ or $x = -\frac{1}{2} - \frac{3}{2}$, Either, $x = \frac{2}{2}$ or $x = -\frac{4}{2}$

Either, x = 1or x = -2 (7 ½ mrks)

SECTION C

6. $3x^2 - 8x - 3 = 0$

Comparing coefficients

a = 3, b = -8 and c = -3

Substituting the values in the formula we get

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

$x = \frac{- -8 \pm \sqrt{(-8^2)\ x\ -4\ x\ 3\ -3}}{2\ x\ 3}$

$x = \frac{8 \pm \sqrt{64+36}}{6}$

$x = \frac{8 \pm \sqrt{100}}{6}$

$x = \frac{8 \pm 10}{6}$

Either, $x = \frac{8+10}{6}$ or $x = \frac{8-10}{6}$

Either, $x = \frac{18}{6}$ or $x = \frac{-2}{6}$

Either, $x = 3$ or $x = -\frac{1}{3}$ (7 ½ mrks)

7. $2x^2 + x - 3 = 0$

Comparing coefficients

$a = 2$, $b = 1$ and $c = -3$

Substituting the values in the formula we get

$x = \frac{-1 \pm \sqrt{1^2 - 4 \times 2 \times -3}}{2 \times 2}$

$x = \frac{-1 \pm \sqrt{(1^2) \times -4 \times 2 \times -3}}{2 \times 2}$

$x = \frac{-1 \pm \sqrt{1+24}}{4}$

$x = \frac{-1 \pm \sqrt{25}}{4}$

$x = \frac{-1 \pm 5}{4}$

Either, $x = \frac{-1+5}{4}$ or $x = \frac{-1-5}{4}$

Either, $x = \frac{4}{4}$ or $x = -\frac{6}{4}$

Either, $\underline{x = 1}$ or $\underline{x = -\frac{3}{2}}$ (7 ½ marks)

8. $x^2 - 2x - 8 = 0$

Comparing coefficients

$a = 1$, $b = -2$ and $c = -8$

Substituting the values in the formula we get

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

$x = \frac{- -2 \pm \sqrt{(-2^2) - 4 \times 1 \times -8}}{2 \times 1}$

$x = \frac{2 \pm \sqrt{4+32}}{2}$

$x = \frac{2 \pm \sqrt{36}}{2}$

$x = \frac{2 \pm 6}{2}$

Either, $x = \frac{2+6}{2}$ or $x = \frac{2-6}{2}$

Either, $x = \frac{8}{2}$ or $x = \frac{-4}{2}$

Either, $x = 4$ or $x = -2$ (7 ½ marks)

APPENDIX D

NEWMAN ERRORS RESULTS FOR EXPERIMENTAL GROUP

BEFORE TREATMENT

Table 3.8.1: Errors Committed in Factorization (Before Treatment)

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
1	01	02	06	04	03	02	18
2	03	04	04	07	04	02	23
Total	**04**	**06**	**10**	**11**	**07**	**04**	**43**

Table 3.8.1; above descried the type of error committed by the students in factorization method

Table 3.8.2: Newman Errors Committed in Completing the Square (Before Treatment)

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
3	02	04	05	05	05	03	24
4	04	03	06	04	03	01	21
Total	**06**	**07**	**11**	**09**	**08**	**04**	**45**

Table 3.8.3: Newman Errors Committed in Quadratic Formula (Before Treatment)

Table 3.8.2 ; above descried error committed by the students in completing square method

Table 3.8.4: Newman Errors Committed in Graphical method (Before Treatment)

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
5	03	03	06	04	04	03	23
6	02	04	04	06	01	01	18
Total	**05**	**07**	**10**	**10**	**05**	**04**	**41**

NEWMAN ERRORS RESULTS FOR EXPERIMENTAL GROUP

AFTER TREATMENT

Table 3.5 Errors Committed in Factorization Method (After Treatment)

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
1	02	02	03	04	03	01	16
2	01	02	04	03	02	02	25
Total	**03**	**04**	**07**	**07**	**05**	**03**	**41**

Table 3.5: above descried the type of errors committed by the students in factorization method

Table 3.5 Errors Committed in Completing the Square Method (After Treatment)

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
3	03	02	03	03	03	01	15
4	01	02	04	05	02	01	15
Total	**04**	**04**	**07**	**08**	**05**	**02**	**30**

Table 3.8: Errors Committed in using Quadratic Formula Method

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
5	02	01	05	02	02	02	14
6	02	03	02	04	01	02	14
Total	**04**	**04**	**07**	**06**	**03**	**04**	**28**

Table 3.6: descried type of error committed by the students in completing the square method

Table 3.8: Errors Committed in using Graphical Method

Item	Reading comprehension	Transformation	Process Skill	Encoding	Carelessness	Total
7	01	02	021	03	01	02	11
8	03	01	04	04	01	01	12
Total	**04**	**03**	**06**	**07**	**02**	**03**	**23**

Table 3.8; above descried the type of error committed by the students in quadratic formula

Table 3.8: Summary of Errors Committed by Experimental Group (After Treatment)

S/N	Err. Typ.	Read	Com	Tran	Proc	Enc	Car	Male error	Female Error	Total error
1	Factorize. Method	04	05	12	13	04	03	19	22	41
2	Comp. the square	04	04	16	18	04	02	21	27	48
3	Formula method	03	06	15	11	05	04	19	24	43
4	Graphical method	03	03	14	15	04	04	16	27	43
	Total	14	18	57	57	17	12	75	108	176

Source: (Journal of International and Cooperation in Education 9(1), 111-122).Key: Typ = Type, Err = Error, Red = Reading, Com = Comprehension, Tran = Transformation, Proc = Process skill, Enc = Encoding, Car = Carelessness, Mal = Male, Fem = Female

NEWMAN ERRORS RESULTS FOR CONTROL GROUP

BEFORE TREATMENT

Table 3.8.4: Errors Committed in Factorization (Before Treatment)

Item	Reading comprehension	Transformation Process Skill	Encoding	Carelessness	Total
1	03	04	08	09	05	03	32
2	04	06	11	09	07	04	41
Total	**07**	**10**	**19**	**18**	**12**	**07**	**73**

Table 3.8.4; above represent the type of errors in factorization method

Table 3.8.5: Errors Committed in Completing the Square (Before Treatment)

Item	Reading comprehension	Transformation Process Skill	Encoding	Carelessness	Total
3	05	06	08	11	09	04	43
4	05	05	10	09	04	02	35
Total	**10**	**11**	**18**	**20**	**13**	**06**	**78**

Table 3.8.5; above represent the type of error in completing the square method

Table 3.8.5: Errors Committed in Quadratic Formula (Before Treatment)

5	06	04	12	08	04	07	41
6	03	05	05	09	04	04	30
Total	**09**	**09**	**17**	**17**	**08**	**11**	**71**

Table 3.8.5; above represent the type of error in Quadratic Formula Method

Table 3.8.6: Errors Committed in Graphical Method (Before Treatment)

Item	Reading	Comprehension	Transformation Proc.	Skill	Encoding	Careless	
7	03	06	09	09	02	02	31
8	03	03	06	08	03	03	26
Total	**06**	**09**	**15**	**17**	**05**	**05**	**57**

Table 3.8.6; above represent the type of errors in quadratic formula

Control Group before Treatment

Table 4.3: **Table of Specification of NEDT (Pretest) Control Group**

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error
1	Factorization Method	07	10	18	18	12	07	24	48	72
2	Completing the Square Method	10	11	18	20	13	06	26	52	78
3	Formula method	09	09	17	17	08	11	24	47	71
4	Graphical method	06	09	15	17	05	05	19	38	57
5	Total	32	39	68	72	38	29	123	155	278
6	Percentage Error (%)	14.0	36.6	32.8	8.0	7.6	2.9	32.3	67.7	100%

NEWMAN ERRORS FOR CONTROL GROUP
AFTER TREATMENT

Table 3.8.4: Errors Committed in Factorization (After Treatment)

1	02	05	10	09	06	03	35
2	04	03	04	05	03	02	21
Total	**06**	**08**	**14**	**14**	**09**	**05**	**56**

Table 3.8.4; above represent the type of errors in factorization method

Table 3.8.5: Errors Committed in Completing the Square (After Treatment)

3	04	02	09	07	04	06	32
4	03	05	05	06	03	03	25
Total	**07**	**07**	**14**	**13**	**07**	**09**	**57**

Table 3.8.5: Errors Committed in Quadratic Formula (After Treatment)

3	02	03	08	08	03	04	43
4	05	04	06	05	04	05	35
Total	**07**	**07**	**14**	**13**	**07**	**09**	**78**

Table 3.8.5; above represent the type of errors in completing the square method

Table 3.8.6: Errors Committed in Graphical Method (After Treatment)

3	03	02	06	08	01	01	21
4	02	05	06	06	03	03	25
Total	**05**	**07**	**12**	**14**	**04**	**04**	**46**

Table 3.8.6; above descried the type of error committed by the students in quadratic formula

Control Group after Treatment

Table 4.3: **Table of Specification of NEDT (Posttest) Control Group**

S/n	Err/Content	Read	Com	Tran	Proc	Enc	Car	Mal Err	Fem Err	Total Error
1	Factorization Method	06	08	14	14	09	05	20	36	56
2	Completing the Square Method	08	09	14	16	10	05	21	41	62
3	Formula method	07	07	14	13	07	09	19	38	57
4	Graphical method	05	07	12	14	04	04	15	31	46
5	Total	32	39	68	72	38	29	73	146	221
6	Percentage Error (%)	14.0	36.6	32.8	8.0	7.6	2.9	32.3	67.7	100%

APPENDIX E

Schedule of Teaching the Groups by Week Day and Hour

Week	Day	Hour	Group	Treatment
1	Friday	10-12am	Experimental Group	IDM
	Saturday	10-12am	Lecture Method	LM
2	Friday	10-12am	Experimental Method	IDM
	Saturday	10-12am	Lecture Method	LM
3	Friday	10-12am	Experimental Method	IDM
	Saturday	10-12am	Lecture Method	LM
4	Friday	10-12am	Experimental Method	IDM
	Saturday	10-12am	Lecture Method	LM
5	Friday	10-12am	Experimental Method	IDM
	Saturday	10-12am	Lecture Method	LM
6	Friday	10-12am	Experimental Method	IDM
	Saturday	10-12am	Lecture Method	LM

Note:

LM = Lecture Method

IDM= Inquiry-Demonstration Method

APPENDIX F

PRETEST PERFORMANCE SCORE FOR EXPERIMENTAL GROUP

No	STUDENTS GENDER	SECTION I	SECTION II	SECTION III	TOTAL
1	MALE	02	01	01	05
2	MALE	03	05	02	10
3	MALE	05	07	08	20
4	MALE	02	05	04	11
5	MALE	05	02	01	08
6	MALE	10	07	07	24
7	MALE	05	06	10	21
8	MALE	08	02	10	20
9	MALE	10	07	13	30
10	MALE	04	06	06	16
11	MALE	06	05	09	20
12	MALE	03	02	03	08
13	MALE	07	03	04	14
14	MALE	01	02	02	05
15	MALE	03	02	02	07
16	MALE	05	10	07	22
17	MALE	03	01	01	05
18	MALE	03	06	02	11
19	MALE	01	02	01	04
20	MALE	10	09	03	22
21	MALE	05	06	04	15
22	MALE	03	06	11	20
23	MALE	13	05	05	23
24	MALE	07	10	09	26
25	MALE	03	10	07	20
26	MALE	00	01	03	04
27	MALE	10	10	03	23
28	MALE	05	15	05	20
29	MALE	05	02	01	08
30	MALE	09	10	10	29
31	MALE	03	02	05	10
32	MALE	06	08	01	15
33	MALE	03	06	05	14
34	MALE	10	09	03	22
35	MALE	05	10	10	25
36	MALE	02	01	01	05
37	MALE	03	05	02	10
38	MALE	05	07	08	20

39	MALE	02	05	04	11
40	MALE	05	02	01	08
41	MALE	10	07	07	24
42	MALE	05	06	10	21
43	MALE	08	02	10	20
44	MALE	10	07	13	30
45	MALE	04	06	06	16
46	MALE	06	05	09	20
47	MALE	03	02	03	08
48	MALE	07	03	04	14
49	MALE	01	02	02	05
50	MALE	03	02	02	07
51	FEMALE	04	05	05	14
52	FEMALE	02	07	14	22
53	FEMALE	02	03	03	08
54	FEMALE	03	15	15	33
55	FEMALE	01	02	03	06
56	FEMALE	07	10	04	21
57	FEMALE	13	09	11	33
58	FEMALE	02	03	05	10
59	FEMALE	02	08	12	22
60	FEMALE	09	05	05	19
61	FEMALE	06	10	10	26
62	FEMALE	02	18	12	24
63	FEMALE	06	12	08	26
64	FEMALE	02	03	13	22
65	FEMALE	03	02	03	08
66	FEMALE	12	15	15	42
67	FEMALE	13	17	13	43
68	FEMALE	12	09	11	32
69	FEMALE	03	03	03	09
70	FEMALE	12	09	11	32
71	FEMALE	07	08	06	21
72	FEMALE	06	09	11	26
73	FEMALE	02	05	01	08
74	FEMALE	02	08	12	22
75	FEMALE	05	05	10	20
76	FEMALE	05	05	05	15
77	FEMALE	04	09	11	24
78	FEMALE	02	02	04	08
79	FEMALE	10	15	05	30
80	FEMALE	04	05	11	20
81	FEMALE	02	02	04	08
82	FEMALE	13	20	20	33
83	FEMALE	05	10	05	20
84	FEMALE	04	10	10	24
85	FEMALE	13	09	11	33

POSTTEST PERFORMANCE SCORE

EXPERIMENTAL GROUP

No	STUDENTS GENDER	SECTION I	SECTION	SECTION	TOTAL
1	MALE	19	14	16	49
2	MALE	10	22	18	60
3	MALE	17	15	15	47
4	MALE	10	18	12	40
5	MALE	19	15	15	59
6	MALE	18	13	17	48
7	MALE	20	16	24	60
8	MALE	19	13	17	49
9	MALE	20	20	19	59
10	MALE	23	18	22	63
11	MALE	21	18	22	61
12	MALE	16	17	13	46
13	MALE	20	30	30	80
14	MALE	12	12	18	42
15	MALE	18	14	16	48
16	MALE	19	20	20	49
17	MALE	23	16	24	63
18	MALE	12	13	17	52
19	MALE	26	18	22	66
20	MALE	20	24	16	60
21	MALE	08	12	18	38
22	MALE	23	12	18	53
23	MALE	19	18	12	49
24	MALE	26	19	21	66
25	MALE	22	26	18	66
26	MALE	18	15	15	48
27	MALE	25	16	14	55
28	MALE	13	15	15	53
29	MALE	20	18	22	60
30	MALE	21	20	20	61
31	MALE	16	18	12	46
32	MALE	26	15	15	56
33	MALE	13	17	13	43
34	MALE	19	12	18	49
35	MALE	19	20	20	59
36	MALE	25	26	24	55
37	MALE	18	17	13	48
38	MALE	10	16	14	40
39	MALE	15	12	18	45
40	MALE	18	09	11	38

41	MALE	19	15	15	49
42	MALE	21	19	21	61
43	MALE	16	18	22	46
44	MALE	20	25	15	60
45	MALE	20	35	25	80
46	MALE	23	20	20	63
47	MALE	13	16	14	43
48	MALE	17	12	18	47
49	MALE	22	27	23	72
50	MALE	28	35	25	88
51	FEMALE	29	12	18	59
52	FEMALE	24	18	22	64
53	FEMALE	25	35	17	77
54	FEMALE	27	28	32	87
55	FEMALE	19	25	25	69
56	FEMALE	19	20	20	59
57	FEMALE	26	25	25	76
58	FEMALE	18	28	22	68
59	FEMALE	18	12	18	48
60	FEMALE	23	22	18	63
61	FEMALE	08	11	09	28
62	FEMALE	15	15	25	55
63	FEMALE	08	17	13	38
64	FEMALE	07	15	15	37
65	FEMALE	17	27	23	67
66	FEMALE	07	08	06	21
67	FEMALE	17	18	12	47
68	FEMALE	16	09	11	36
69	FEMALE	13	17	13	43
70	FEMALE	23	18	22	63
71	FEMALE	10	15	15	40
72	FEMALE	19	23	17	59
73	FEMALE	26	20	20	66
74	FEMALE	11	09	11	31
75	FEMALE	15	24	26	65
76	FEMALE	14	09	11	34
77	FEMALE	20	18	12	50
78	FEMALE	23	20	20	63
79	FEMALE	11	19	21	51
80	FEMALE	19	26	14	59
81	FEMALE	19	10	10	39
82	FEMALE	22	20	20	62
83	FEMALE	23	19	21	63
84	FEMALE	10	10	22	42
85	FEMALE	28	15	15	58

APPENDIX G

PRETEST PERFORMANCE SCORE
CONTROL GROUP

No	STUDENTS GENDER	SECTION I	SECTION II	SECTION III	TOTAL
1	MALE	03	10	07	20
2	MALE	08	09	11	28
3	MALE	02	03	07	12
4	MALE	01	01	02	04
5	MALE	03	08	12	23
6	MALE	04	06	14	24
7	MALE	01	08	12	21
8	MALE	02	06	04	12
9	MALE	01	08	12	21
10	MALE	06	07	13	26
11	MALE	01	03	07	11
12	MALE	04	06	14	24
13	MALE	06	03	07	16
14	MALE	00	01	02	03
15	MALE	04	07	13	24
16	MALE	09	11	01	21
17	MALE	03	03	03	09
18	MALE	03	07	13	23
19	MALE	02	03	02	07
20	MALE	02	05	05	12
21	MALE	05	03	07	15
22	MALE	06	09	11	26
23	MALE	03	02	04	09
24	MALE	03	02	03	08
25	MALE	02	03	00	05
26	MALE	05	00	03	08
27	MALE	04	07	13	24
28	MALE	05	10	05	20
29	MALE	00	01	02	03
30	MALE	08	06	04	18
31	MALE	06	09	11	26
32	MALE	09	10	02	21
33	MALE	03	02	02	07
34	MALE	06	05	05	16
35	MALE	03	05	05	13
36	MALE	02	09	11	22
37	MALE	02	03	05	10
38	MALE	00	01	03	04
39	MALE	01	05	05	11
40	MALE	02	03	03	08

41	MALE	01	05	02	08
42	MALE	03	04	06	13
43	MALE	02	03	03	08
44	MALE	10	09	11	30
45	MALE	02	03	07	12
46	MALE	01	03	02	06
47	MALE	07	02	08	17
48	MALE	10	04	06	20
49	MALE	02	03	02	07
50	MALE	04	03	02	09
51	MALE	07	07	13	27
52	MALE	02	04	16	22
53	MALE	01	10	10	21
54	MALE	10	09	04	23
55	MALE	10	11	10	31
56	MALE	04	03	02	09
57	MALE	01	02	02	05
58	MALE	13	09	11	33
59	MALE	06	03	11	20
60	MALE	04	06	10	20
61	MALE	08	11	09	28
62	MALE	15	15	25	55
63	MALE	08	17	13	38
64	FEMALE	07	15	15	37
65	FEMALE	17	27	23	67
66	FEMALE	07	08	06	21
67	FEMALE	17	18	12	47
68	FEMALE	16	09	11	36
69	FEMALE	13	17	13	43
70	FEMALE	23	18	22	63
71	FEMALE	10	15	15	40
72	FEMALE	19	23	17	59
73	FEMALE	26	20	20	66
74	FEMALE	11	09	11	31
75	FEMALE	15	24	26	65
76	FEMALE	14	09	11	34
77	FEMALE	20	18	12	50
78	FEMALE	23	20	20	63
79	FEMALE	11	19	21	51
80	FEMALE	19	26	14	59
81	FEMALE	19	10	10	39
82	FEMALE	22	20	20	62
83	FEMALE	23	19	21	63
84	FEMALE	10	10	22	42
85	FEMALE	28	15	15	58
86	FEMALE	02	01	01	05
87	FEMALE	03	05	02	10

88	FEMALE	05	07	08	20
89	FEMALE	02	05	04	11
90	FEMALE	05	02	01	08
91	FEMALE	10	07	07	24
92	FEMALE	05	06	10	21
93	FEMALE	08	02	10	20
94	FEMALE	10	07	13	30
95	FEMALE	04	06	06	16
96	FEMALE	06	05	09	20
97	FEMALE	03	02	03	08
98	FEMALE	07	03	04	14
99	FEMALE	01	02	02	05
100	FEMALE	03	02	02	07
101	FEMALE	05	10	07	22

CONTROL GROUP

POSTTEST PERFORMANCE SCORE

No	STUDENTS GENDER	SECTION I	SECTION	SECTION	TOTAL
1	MALE	08	11	09	28
2	MALE	15	15	25	55
3	MALE	08	17	13	38
4	MALE	07	15	15	37
5	MALE	17	27	23	67
6	MALE	07	08	06	21
7	MALE	17	18	12	47
8	MALE	16	09	11	36
9	MALE	13	17	13	43
10	MALE	23	18	22	63
11	MALE	10	15	15	40
12	MALE	19	23	17	59
13	MALE	26	20	20	66
14	MALE	11	09	11	31
15	MALE	15	24	26	65
16	MALE	14	09	11	34
17	MALE	20	18	12	50
18	MALE	23	20	20	63
19	MALE	11	19	21	51
20	MALE	19	26	14	59
21	MALE	19	10	10	39
22	MALE	22	20	20	62
23	MALE	23	19	21	63
24	MALE	10	10	22	42
25	MALE	28	15	15	58
26	MALE	23	17	13	53
27	MALE	21	20	20	61
28	MALE	18	24	16	58
29	MALE	11	16	04	31
30	MALE	13	09	11	33
31	MALE	20	24	16	60
32	MALE	15	09	11	35
33	MALE	22	16	14	52
34	MALE	26	21	19	66
35	MALE	19	18	12	49
36	MALE	11	16	14	41
37	MALE	18	23	17	48
38	MALE	20	23	27	70
39	MALE	25	12	18	65

40	MALE	16	13	17	46
41	MALE	23	17	13	63
42	MALE	15	20	10	45
43	MALE	18	15	15	48
44	MALE	23	16	11	50
45	MALE	23	19	11	63
46	MALE	18	10	10	38
47	MALE	15	10	25	50
48	MALE	18	17	13	48
49	MALE	13	16	14	43
50	MALE	27	18	12	57
51	MALE	19	15	15	49
52	MALE	08	12	08	28
53	MALE	23	24	17	64
54	MALE	09	16	14	39
55	MALE	10	19	21	50
56	MALE	19	20	20	59
57	MALE	26	25	15	66
58	MALE	16	05	05	26
59	MALE	20	17	13	50
60	MALE	22	16	14	52
61	MALE	08	11	09	28
62	MALE	15	15	25	55
63	MALE	08	17	13	38
64	FEMALE	07	15	15	37
65	FEMALE	17	27	23	67
66	FEMALE	07	08	06	21
67	FEMALE	17	18	12	47
68	FEMALE	16	09	11	36
69	FEMALE	13	17	13	43
70	FEMALE	23	18	22	63
71	FEMALE	10	15	15	40
72	FEMALE	19	23	17	59
73	FEMALE	26	20	20	66
74	FEMALE	11	09	11	31
75	FEMALE	15	24	26	65
76	FEMALE	14	09	11	34
77	FEMALE	20	18	12	50
78	FEMALE	23	20	20	63
79	FEMALE	11	19	21	51
80	FEMALE	19	26	14	59
81	FEMALE	19	10	10	39
82	FEMALE	22	20	20	62
83	FEMALE	23	19	21	63
84	FEMALE	10	10	22	42
85	FEMALE	28	15	15	58
86	FEMALE	02	01	01	05

87	FEMALE	03	05	02	10
88	FEMALE	05	07	08	20
89	FEMALE	02	05	04	11
90	FEMALE	05	02	01	08
91	FEMALE	10	07	07	24
92	FEMALE	05	06	10	21
93	FEMALE	08	02	10	20
94	FEMALE	10	07	13	30
95	FEMALE	04	06	06	16
96	FEMALE	06	05	09	20
97	FEMALE	03	02	03	08
98	FEMALE	07	03	04	14
99	FEMALE	01	02	02	05
100	FEMALE	03	02	02	07
101	FEMALE	05	10	07	22

APPENDIX H

CALCULATION OF RELIABILITY OF QUADRATIC EQUATION PERFORMANCE TEST (QEPT) AFTER TEST AND RE-TEST ADMINISTRATION USING PPMCC STATISTICS

SN OF STUDENTS	TEST (X)	RE-TEST Y	(X^2)	(Y^2)	(XY)
1	60	65	3600	4225	3900
2	70	65	4900	4225	4500
3	30	40	900	1600	1200
4	50	60	2500	3600	3000
5	65	70	4225	4900	4550
6	50	55	2500	3025	2700
7	35	45	1225	2025	1575
8	30	40	900	1600	1200
9	60	60	3600	3600	3600
10	60	60	3600	3600	3600
11	45	55	2025	3025	2475
12	50	50	2500	2500	2500
13	45	45	2025	2025	2025
14	70	70	4900	4900	4900
15	60	70	3600	4900	4200
16	60	55	3600	3025	3300
17	60	60	3600	3600	3600
18	45	50	2025	2500	2250
19	60	65	3600	4225	3900
20	30	45	900	2025	1350
21	50	55	2500	3025	2750
22	60	65	3600	4225	3900
23	30	35	900	1225	1050
24	50	45	2500	2025	2250
25	55	65	3025	4225	3575
26	40	65	1600	4225	2640
27	45	70	2025	4900	3150
28	50	60	2500	3600	3000
29	60	40	3600	1600	2400
30	70	50	4900	4900	3500
TOTAL	**1545**	**1675**	**83875**	**94850**	**88540**

$$r = \frac{N\Sigma xy - \Sigma x\Sigma y}{\sqrt{[N\Sigma x^2 - (\Sigma x)^2]\,[N\Sigma y^2 - (\Sigma y)^2]}}$$

$$r = \frac{30(88540) - (1545)\,(1675)}{\sqrt{[30(83875) - (1545)^2]\,[30(94850) - (1675)^2]}}$$

$$r = \frac{265620 - 259290}{\sqrt{(2526250) - (2387025)\,(2845500) - 2805625)}}$$

$$r = \frac{6330}{\sqrt{(129329)\,(39979)}}$$

$$\frac{6330}{\sqrt{(5152846875)}}$$

$$= \frac{6330}{7178.33285}$$

$$= 0.8818$$

APPENDIX I

CALCULATION OF RELIABILITY OF NEWMAN ERRORS DIAGNOSTIC TEST AFTER TEST AND RE-TEST ADMINISTRATION USING PPMCC STATISTICS

SN OF STUDENTS	TEST (p)	RE-TEST (q)	(p^2)	(q^2)	(pq)
1	05	07	25	16	20
2	04	03	16	09	12
3	03	04	09	16	12
4	07	03	49	09	21
5	06	04	36	16	24
6	04	05	16	25	20
7	08	04	64	16	32
8	04	04	16	16	14
9	07	06	49	36	42
10	06	06	36	36	36
11	02	08	04	64	16
12	05	03	25	09	15
13	08	04	64	16	32
14	07	05	49	25	35
15	06	06	36	36	36
16	04	03	16	09	12
17	07	04	49	16	28
18	06	06	36	36	36
19	03	04	09	16	12
20	07	05	49	25	35
21	06	03	36	09	18
22	09	03	81	09	27
23	03	04	09	16	12
24	06	04	36	16	24
25	06	05	36	25	30
26	04	04	16	16	16
27	04	04	16	16	16
28	04	03	04	09	12
29	08	04	68	16	32
30	08	08	64	25	64
TOTAL	**165**	**130**	**1019**	**589**	**755**

$$r = \frac{N\Sigma pq - \Sigma p\Sigma q}{\sqrt{[N\Sigma p^2 - (\Sigma p)^2]\,[N\Sigma q^2 - (\Sigma q)^2]}}$$

$$r = \frac{30(755) - (165)\,(130)}{\sqrt{[30(1019) - (165)^2]\,[30(589) - (130)^2]}}$$

$$r = \frac{22650 - 21450}{\sqrt{(30570) - 27225)\,(17670) - 16900)}}$$

$$r = \frac{1200}{\sqrt{(3345)\,(770)}}$$

$$= \frac{1200}{\sqrt{(2575650)}}$$

$$= \frac{1200}{1604.8831}$$

$$= 0.748$$

APPENDIX J

RESEARCH ADVISORS

Required Sample Size[1]

Population Size	Confidence = 95% Margin Of Error				Confidence = 95% Margin Of Error			
	5.0%	**3.5%**	**2.5%**	**1.0%**	**5.0%**	**3.5%**	**2.5%**	**1.0%**
10	10	10	10	10	10	10	10	10
20	19	20	20	20	19	20	20	20
30	28	29	29	30	29	29	30	30
50	44	47	48	50	47	48	49	50
75	63	69	72	74	67	71	73	75
100	80	89	94	99	87	93	96	99
150	108	126	137	148	122	135	142	149
200	132	160	177	196	154	174	186	198
250	152	190	215	244	182	211	229	246
300	169	217	251	291	207	246	270	295
400	196	265	318	384	250	309	348	391
500	217	306	377	475	285	365	421	485
600	234	340	432	565	315	416	490	579
700	248	370	481	653	341	462	554	672
800	260	396	526	739	363	503	615	763
1,000	278	440	606	906	399	575	727	943
1,200	291	474	674	1067	427	636	827	1119
1,500	306	515	759	1297	460	712	959	1376
2,000	322	563	869	1655	498	808	1141	1785
2,500	333	597	952	1984	524	879	1288	2173
3,500	346	641	1068	2565	558	977	1510	2890
5,000	357	678	1176	3288	586	1066	1734	3842
7,500	365	710	1275	4211	610	1147	1960	5165
10,000	370	727	1332	4899	622	1193	2098	6239
25,000	378	760	1448	6939	646	1285	2399	9972
50,000	381	772	1491	8056	655	1318	2520	12455
75,000	382	776	1506	8514	658	1330	2563	13583
100,000	383	778	1513	8762	659	1336	2585	14227
250,000	384	782	1527	9248	662	1347	2626	15555
500,000	384	783	1532	9423	663	1350	2640	16055
1,000,000	384	783	1534	9512	663	1352	2647	16317
2,500,000	384	784	1536	9567	663	1353	2651	16478
10,000,000	384	784	1536	9594	663	1354	2653	16560
100,000,000	384	784	1537	9603	663	1354	2654	16584
300,000,000	384	784	1537	9603	663	1354	2654	16586

Sample Size Table* From the Research Advisors (2006)

APPENDIX K

MODIFIED NEWMAN INTERVIEW

The model was adapted to Modified Newman Interactive Schedule from Modified Newman interview. This was because in the process involved students and the researcher in the taught process during the interaction following the schedule. Modified Newman Interactive Schedule was purposely designed for those students who failed the written test, to find out why and how the Newman errors are committed by the students? The procedures include.

- Can you read the question? (Reading level)
- What does the question ask you to do? (Comprehension level)
- What do you use to solve the question? (Transformation level)
- Can you show the working steps that you have used to find the answer? (Process skill level)
- Tell me what is your answer? (Encoding level).

From the total number of thirty (30) students of the pilot school seven (7) students were not able to answer the written test correctly. The affected students were subjecting to the Modified Newman Interview which was a thought process. Three out of the victims were able to answer the thought process correctly. By implication the reasons for their failure was as a result of carelessness according to Newman. On the other hand the other four students who were not able to answer the thought process correctly were carried alone through the process to find out why and how the errors were committed?

APPENDIX L

SCHEFFE'S RESULTS OF THE ANALYSIS OF ANALYSIS OF VARIANCE (ANOVA)

ANOVA

		Sum of Squares	Df	Mean Square	F	Sig.
VAR00002	Between Groups	3226.700	15	215.113	1.989	.266
	Within Groups	432.500	4	108.125		
	Total	3659.200	19			
VAR00003	Between Groups	3873.250	15	258.217	1.649	.336
	Within Groups	626.500	4	156.625		
	Total	4499.750	19			
VAR00004	Between Groups	6319.050	15	421.270	1.603	.347
	Within Groups	1051.500	4	262.875		
	Total	7370.550	19			
VAR00005	Between Groups	4875.450	15	325.030	.933	.595
	Within Groups	1393.500	4	348.375		
	Total	6268.950	19			

The Schaffer's Test results indicated no significant difference among the sampled schools. Hence, G.S.S. Kaura and G.S.S. Tudun -Jukun all in Zaria Education Zone were selected as the sample schools where G.S.S Kaura represents the experimental group and G.S.S Tudun-Jukun the control group.