EFFECTS OF ANALYTIC AND CREATIVE PROBLEM-SOLVING ON INTEREST AND PERFORMANCE IN MATHEMATICS AMONG SENIOR SECONDARY SCHOOL STUDENTS, SABON-GARI KADUNA STATE,NIGERIA.

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FEBRUARY, 2021.

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BEING A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATESTUDIES, AHMADU BELLO UNIVERSITY, IN PARTIAL FULFILLMENTFORTHE AWARD OF MASTER DEGREE IN MATHEMATICSEDUCATION,DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF EDUCATION. AHMADU BELLO UNIVERSITY, ZARIA.

FEBRUARY, 2021.

DECLARATION

I, Rabiu Mohammed SANI (P15EDSC8028) hereby declare that this dissertation titled: Effects of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari, kaduna state, Nigeria has been written by me in the Department of Science Education under the supervision of Prof. M. Musa and Dr. M. O Ibrahim. The information derived from the literature was duly acknowledged. It has not been presented in any previous application for a higher degree all quotations and sources of information are fully acknowledged by means of references.

_____ _____

Rabiu Mohammed SANI DATE

CERTIFICATION

The dissertation titled "Effects of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari Kaduna State, Nigeria, by Rabiu Mohammed SANI (P15EDSC8028) meets the regulations governing the award degree of Master in Mathematics Education, in Science Education. Ahmadu Bello University, Zaria, and is approved for its contributions to knowledge and literary presentation.

_____

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DEDICATION

This work is dedicated to Almighty Allah, Prophet Muhammad (S.A.W) and my late father Rabiu Ya'u, my mother Halima Rabiu, my late Aunty Hajiya Aisha Uwani (May Allah bless them with aljannah firdaus Amen) and my wife Zubaida Salihu. May Allahbless them all.

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ABBREVIATIONS

ACPSS	Analytic and Creative Problem Solving
APSS	Analytic Problem Solving
APT	Analytic Performance Test
CPT	Creative Performance Test
CCSS	Common Core State Standards Initiative
CPSS	Creative Problem Solving
LTL	Learning to Learn
ISPS	Ill-Structure Problem Solving
IQ	Intelligent Quotient
MAN	Mathematics Association of Nigeria
MIDYIS	Mathematics Achievement Instrument that has been used Nation wide
NERDC	Nigeria Education and Research Development Council
NCTM	National Council of Teachers of Mathematics
PPMC	Pearson Product Moment Correlation
SS2	Senior Secondary 2
SPSS	Statistical Package for Social Science
SSCE	Senior Secondary Certificate Examination
SPIQ	Students Performance Interest Questionnaire

SQ3R	Survey Question Read Recite Review
STAN	Science Teachers Association
USA	United State 0f America
TAPS	Think Aloud Paired Problem Solving

OPERATIONAL DEFINITION OF TERMS

Analytic Problem-Solving; approach is the use of an appropriate process to break a problem down into the smaller pieces necessary to solve it, each piece becomes a smaller and easier problem to solve.

Creative Problem-Solving**;** is a way of solving problem or identifying opportunities when conventional thinking has failed.

Interest;the feeling of wanting to know or learn about something or someone

Academic Performance; a measure of what a person has accomplished after exposure to an educational programme.

Gender; is defined as the amount of masculinity and feminity found in a person.

Lecture Method; is a pedagogical strategy in which a lecturer presents his lesson to a large number of students verbally but with little participation from the students.

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ABSTRACT

This study investigated the effects of analytic and creative problem-solving on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari Kaduna State, Nigeria. The objectives of this study were therefore, to determine the differences between Analytic and Creative Problem Solving on performance of Students in Mathematics, and to determine the effects of academic performance of students taught mathematics, using Analytic Problem-Solving and those taught with lecture method, the study also set out to investigate whether there was difference between the performance of students taught mathematics using Creative Problem-Solving and those taught with lecture method, it also investigate the performance of male and female students using Analytic and Creative Problem-Solving, so as to determine students interest before and after taught mathematics using Analytic and Creative Problem-Solving. Three Senior Secondary Schools in Sabon-Gari Local Govt of Kaduna State were randomly selected using stratified random sampling process was assigned by balloting to each experimental group and the other schools were for control group, the population collected was 130 students out of the total population of 2142 (Two thousand one hundred and forty two)students, using Krejcie & Morgan (1970). Both experimental groups received treatment. Three instruments were designed for data collection but were pilot tested to ascertain their reliability. The validity of the instruments was checked by experts from Department of Science Education Mathematics Section A.B.U Zaria and C.O.E Zaria. The instruments were administered to two groups. Descriptive Statistics (mean, and standard Deviation) and inferential statistics (t-test and Kruskal-Wallis test) were used for data analysis. The level of significance for acceptance or rejection of hypothesis was set at 0.05. The results indicated that students taught using Analytic Problem-Solving Performance Test (APT) and Creative Problem-Solving Performance Test (CPT) had significantly higher in mathematics scores then those who was taught with conventional lecture method. It revealed that the teaching of Analytic and Creative Problem-Solving will enabled the students to retain more knowledge on mathematics, than those in the control group. Also the experimental groups taught mathematics using Analytic and Creative Problem-Solving demonstrated favorable and positive interest toward mathematics. Major recommendations from the study are that the teaching of analytic and creative problem-solving senior secondary school should be conducted in a manner that students will effectively understand and learn the approach taught. It should respect the views and ideas of the students since students" participation plays greater role in learners" performance The fact that higher mean was recorded in students" performance through the use of Analytic and Creative problem-solving, calls for teachers to acquaint themselves with the characteristics of this teaching method with a view to enhancing students' performance and outcomes in learning. This could be done through seminars, conferences and workshops to be organized by State government and professional bodies.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

In today's technology-driven society, greater demands have been placed on individuals to interpret and use mathematics to make sense of information and complex situations. Rising learners "performances/achievement in mathematics has become a matter of increased focus in recent years. Improving the quality of teaching mathematics may likely raise students" achievement in mathematics. Current technology and scientific advancement being experienced worldwide requires that Nigerian learners must be taught to go beyond low level comprehension and mere memorization of facts and formula, if they are to become problem solvers of the future. Trainee teachers therefore should be adequately equipped during initial teachers training to be able to develop in their pupils or learners higher-level thinking skills, especially in mathematics.

Mathematics is the backbone of all scientific/technological investigations and all activities of human developments. It is the only language and culture common to all studies (Golfing, 2005; Musa, 2006). Mathematical knowledge has much to offer in solving problems of mankind in everyday living. All professionals, according to Musa (2006) use mathematics in one-way or the other. Examples include: the driver on the steering uses basic knowledge of numeracy in changing gears; the cook in the kitchen uses the concept of measurement in preparing food and soup to know the quantity of what is required for each; the trader in the market tries to know the profit and loss made. Such trader must have knowledge of basic arithmetic. The farmer uses mathematical knowledge for farm mechanization for optimization of output and minimization of cost production where the concept of production, economic differentiation and integration of variables are greatly

utilized. It is in recognition of this that our curriculum planners include mathematics as one of the major and compulsory subjects in the school (F.M.E 2006). Mathematics is the body of knowledge centered on such concepts as quantity, structure and space as well as the academic discipline that studies them. Benjamin (2007) describes mathematics as the science of pattern and relationship which can be expressed in symbols. It embraces many important ideas about number and space which involve problem- solving activities and a very powerful way of communication.

Since the introduction of mathematics in post-primary schools in Nigeria, Nigerian educators and the general public have made criticisms on the poor performance of students in mathematics (Obioma (1985), Adegboye, 1998). According to Ukeje (1997), the poor and alarming state of mathematics education in Nigeria's Secondary School System needs no documentation. The mass failure and consistent poor performance of students in mathematics shown over decades now casts doubts on the country's high attainment in the science and technology. Silby (2002) and Bature (2005) submit that among the factors responsible for the deteriorating performance of the students in mathematics at secondary school level are traceable to poor quality of teaching. Higher level mathematics requires all students to be proficient problem solvers, but as stated previously students struggle with mathematical problem solving. Based on this conceptualization of solving word problems, the mathematical equations are sometimes hidden within multifarious, complex word usage. Sometimes the numerals and numeric operations are difficult to identify due to unforeseen or unique language structures, especially in the most advanced word problems. This results in high levels of challenge for many students in the area of mathematics. Harbor, (2002) has attributed poor using teaching approaches in classroom by teachers as one of the root course of the undesirable poor interest and performances in mathematics. (Kurumeh, Jimin & Mohammed 2010) which are capable of alleviating poor performance of students in the subject. Yet, mathematics

teachers are failing to use these approaches either due to logistic or lack of the provision of essentials needed for teaching. Available records have shown that researchers have discovered a series of teaching approaches like team teaching (Achor, Imo, & Jimin, 2011).

Problem-Solving historically, this notion was first put forth in (Kohler, 1925). However, Polya is often credited with the use of novelty as a component of his definition. For example, Polya (1945 & 1962) described mathematical problem solving approach as finding a way around a difficulty, around an obstacle, and finding a solution to a problem that is unknown. Teachers providing just enough information to establish background/intent of the problem, and learners clarifying, interpreting, and attempting to construct one or more solution processes (Cobb, Wood, Yackel, Nicholls, Wheatley, Trigatti, & Perlwitz, 1991). Many writers have attempted to clarify what is meant by a problem-solving approach to teaching mathematics as the emphasis has shifted from teaching problem solving to teaching through problem solving (Lester, Masingila, Mau, Lambdin, dos Santos & Raymond, 1994). According to Lester et al. (1994), teaching mathematics topics through a problem-solving approach is characterized by the teacher "helping learners construct a deeper understanding of mathematical ideas and processes by engaging them in doing mathematics: creating, conjecturing, exploring, testing, and verifying" Specific characteristics of a problem-solving approach include: Interactions between learners/learners and teachers/ learners (Van Zoest, Jones, & Thornton, 1994). Mathematical dialogue and consensus between learners (Van Zoest et al., 1994). Teachers guiding, coaching, asking insightful questions and sharing in the process of solving problems (Lester et al., 1994). Teacher knowing when it is appropriate to intervene, and when to step back and let the pupils (learners) make their own way (Lester et al., 1994). This list of characteristics on teaching mathematics through a problem-solving approach involves the learner actively learning mathematics by doing, with teacher passively playing the supportive role of teaching by assisting the learner to construct his/her new mathematical knowledge and

understanding. It also involves learners learning in cooperative and collaborative small groups. This type of learning supports constructivism and social-constructivism knowing and learning theories.

A problem-solving approach (a learner-centered approach) involves teaching mathematics topics through inquiry-oriented environments that are characterized by the teacher "helping learners construct a deeper understanding of mathematical ideas and processes by engaging them in doing mathematics: creating, conjecturing, exploring, testing, and verifying" (Lester et al., 1994,). A problem-solving approach can be used to encourage learners to make generalizations about rules and concepts, a process that is central to mathematics (Evan & Lappin, 1994). It also shows an engagement in learning that may lead to the development of higher-order cognitive skills that are rarely developed by learners in more direct/conventional instruction, drill-and-practice classroom activities. A problem-solving approach to teaching mathematics defines the role of the teacher as a facilitator of learning rather than a transmitter of knowledge and the learner, as a manager and director of their own learning. Successful problem solving requires knowledge of mathematical content, knowledge of problem-solving approach, effective self-monitoring, and a productive disposition to pose and solve problems. Teaching problem solving requires even more of teachers, since they must be able to foster such knowledge and attitudes in their students. Looking more closely at problem solving, the conceptual definition of problem solving in mathematics is complex. Possibly the most significant reason for this is because no formal conceptual definition has ever been agreed upon by experts in the field of mathematics education. Furthermore, Bay (2000) explains teaching via problem solving as a method by which mathematics teachers may provide more meaningful instruction. Advancing his argument, Bay (2000) further explains that Teaching *via* problem solving (teaching through a problem-solving) is teaching mathematics content in a problem-solving environment. Lester and Kehle (2003) suggested that reasoning and/or higher

order thinking must occur during mathematical problem solving. Grugnetti and Jaquuet (2005) even suggested that a common definition of mathematical problem solving could not be provided. One term that is often associated with mathematical problem solving is novelty. In the process of solving problems, the students interact with one another and with instructional materials and eventually construct knowledge and acquire the processes of science.

Also Selvarantham (1983), Nott (1987) and Eze, (2001) observed that a systematic approach to problem-solving encourages good learning habits, contributes to clarity in thinking, logical reasoning and promotes intellectual development. Problem-solving teaching is an instructional approach in which problems of scientific nature or problem related to the real world are carefully formulated and presented to students (Bichi, 2002). Bichi (2002) also observed that as students engage in solving problems, they acquire skills and confidence which aid their capacity to tackle future problem. Therefore, as dexterity in solving problem increases, they become more self-confident to tackle novel problems and this is expected to increase their self-esteem/self-efficacy. Thus, it seems students' self-efficacy may increase as they are exposed to problem-solving approach. Danjuma (2005) observed that problem-solving activities encourages the development of problem-solving skills such as logical reasoning ability, In general, when researchers use the term “problem solving approach ‟ in mathematics they are referring to mathematical tasks that have the potential to provide intellectual challenges that can enhance learners‟ mathematical development and hence improve their performance in mathematics. Such tasks also promote learners‟ conceptual understanding, foster their ability to reason and communicate mathematically, capture their interests and curiosity (Van de Walle, 2007). Manipulative skills, self-confidence (self-efficacy) and creativity in learners which may enhance progressive performance.

Analytic problem-solving approach is the use of an appropriate process to break a problem down into the smaller pieces necessary to solve it, each piece becomes a smaller and easier

problem to solve Morgan (1995), and also an Analytic thinker has the ability to get into the detail of a problem, evaluate all components and perspectives to understand it and determine what's missing. Analytic thinker asks questions to fill in any gaps they see in order to foresee next steps. They have confidence in their ability and make assumptions and decision because of their constructive fact finding process. Although their assumption is credible and decision well supported, they may not move quickly enough to a solution if they do not have all the facts. Because their fact-finding process takes time, they not opinions unless specifically asked. Morgan (1995) observed,Problem solving is puzzled solving. Each smaller problem is a smaller piece of the puzzle to find and solve. Putting the pieces of the puzzle together involves understanding the relevant parts of the system. Once all the key pieces are found and understood, the puzzle as a whole "snaps" together, sometimes in a final flash of insight. The key word in the above definition is "appropriate." If your problem solving process doesn't fit the problem at hand, you can execute the process to the highest quality possible and still not solve the problem. This is the reason most people fail to solve difficult problems. They're using an inappropriate approach without realizing it. The process doesn't fit the problem. You can look high and low, and under every bush in plain sight, but unless you're using an appropriate analytic approach you will never find enough pieces of the puzzle to solve a difficult problem. Even the most brilliant and heroic effort will lead to naught if you're using a problem solving process that doesn't fit the problem. Lack of a process that fit the problem is why the alchemists failed to turn lead into gold. It's also why so many people and organizations, as well as entire social movements, are failing to turn opportunities into successes.

Creative Problem Solving (or CPS) is a broadly applicable process providing an organizing framework for specific creative and critical thinking techniques to help design and develop new and useful outcomes for meaningful and important challenges, concerns and

opportunities (Isaksen, Dorval & Treffinger, 1994). CPS is an operational model for a particular kind of problem solving where creativity is applicable for the task at hand. Creative problem solver has the ability to envision several outcomes, make assumptions as to what needs to be done to achieve an outcome and is willing to take risks because they have confidence in their own judgment. Creative thinkers start from scratch and are not limited by steps or processes; instead they create unique path and new solutions. The limitation of creative problem solving is often that there is no limit to the creative process. If a problem has a deadline or budget constraint, creative thinkers may struggle because they have difficult focusing and can lose sight of more obvious solutions (Dorval, 1994).

The first major component in this operational model is called Understanding the Problem which includes a systematic effort to define, construct, or formulate a problem. Although many researchers have focused on problem finding as a process separate from problem solving, such a distinction may be arbitrary especially within the context of a flexible or descriptive approach. It is not necessarily the "first" step in CPS, nor is it necessarily undertaken by all people in every CPS session. Rather than prescribing an essential problem finding process, Understanding the Problem involves active construction by the individual or group through analyzing the task at hand (including outcomes, people, context, and methodological options) to determine whether and when deliberate problem-structuring efforts are needed. The Understanding the Problem component of CPS includes the three stages of Mess-Finding, Data-Finding, and Problem-Finding. A mess is a broad statement of a goal or direction that can be constructed as broad, brief, and beneficial. The Mess generally describes the basic area of need or challenge on which the problem solver's efforts will be focused, remaining broad enough to allow many perspectives to emerge as one (or a group) looks more closely at the situation. Data-Finding includes the generating and answering of questions to bring out key data (information, impressions, observations, feelings, etc.) to help

the problem solver(s) focus more clearly on the most challenging aspects and concerns of the situation. Problem-Finding includes the seeking of a specified or targeted question (Problem statement) on which to focus subsequent effort. Effectively worded problem statements invite an open or wide-ranging search for many, varied and novel options. They are stated concisely and are free from specific limiting criteria.

1.2 Statement of the Research Problem

This study was conceived to determine if exposure to analytic and creative problem-solving approach could affect student's performance/ interest or not. According to Ukeje (1997), the mass failure and consistent poor performance of students in mathematics shown over decades now casts doubts on the country's high attainment in the science and technology. Since the introduction of mathematics in post-primary schools in Nigeria, Nigerian educators and the general public have made criticisms on the poor achievement of students in mathematics (Adegboye, 1998); Silby (2000) and Bature (2005) submit that among the factors responsible for the deteriorating performance of the students in mathematics at secondary school level are traceable to poor quality of teaching. Based on this conceptualization of solving word problems, the mathematical equations are sometimes hidden within multifarious, complex word usage. Especially in the most advanced word problems. This results in high levels of challenge for many students.

Given the fast pace of technological development in our global education economy, business and industry needs Analytic and Creative Problem Solvers to remain competitive. Public education is being asked to play an important role in preparing young people for the challenges of the work place by providing its students with analytic and creative problem solving skills. Both potential skills are developing to engage students in a series of mini lessons on analytic and creative approaches over a period of several weeks. However, the effectiveness of such an approach has not been established. Therefore, the purpose of this

study was to determine Analytic and Creative responses would improve if students were exposed to Analytic and Creative Problem-Solvingon daily basis. This is expected as skills like manipulation, procedure, self-confidence, evaluation, communication and logical reasoning ability among others are related to Analytic and Creative skills. Thus, it seems that exposure to problem-solving could affect the Analytic and Creative subsequent achievement in Genetics. Since poor academic achievement in genetic according to Okebukola (2002), Ibraheem (2004) have been attributed to student's poor manipulative skills, insufficient instructional materials, poor method of teaching employed, mathematical aspect and nature of the genetic concepts. As dexterity in problem-solving builds self-confidence, it may be an indication that exposure to problem-solving could affect analytic and creative learners. Researchers such as Danjuma (2005) have linked Analytic and Creative Problem-Solving has made achievement in science.

1.3 Objectives of the Study

The purpose of this study is to examine the effectiveness of explicit instruction in the Analytic and CreativeProblem Solving on Interest and Performance in Mathematics among Senior Secondary School Students. The study objectives are:

1 To determine the difference between academic performances of students taught using Analytic and Creative Problem-Solving.

2 To determine the effects of academic performance of students taught using Analytic Problem-Solving and those taught using convention lecture method.

3 To investigate whether the performance of students taught mathematics using Creative Problem-Solving was better than those taught using convention lecture method.

4 To determine the performance of male and female students taught using Analytic and Creative Problem-Solving.

5 To determine whether student's interest before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method.

1.4 Research Questions:

1 What are the differences between the performances of students taught using Analytic and Creative Problem-Solving?

2. What are the effect of academic performance of students taught mathematics using Analytic Problem-Solving and those taught using lecture method?

3. To what extent does the performance of the students taught mathematics using Creative Problem-Solving and those taught using lecture method?

4. Are there difference between academic performances of male and female students taught using Analytic and Creative Problem-Solving?

5. To what extent student's response on interest determined before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method?

1.5 Null Hypotheses:

H_{01} There is no significant difference between performance of students taught using Analytic and Creative Problem-Solving.

H_{02} There is no significant difference between performance of students taught mathematics using Analytic Problem-Solving and those using taught using lecture method..

H_{03} There is no significant difference between the performance of students taught mathematics using Creative Problem-Solving and those taught using lecture method.

H_{04} There is no significant difference between the performance of male and female students taught using Analytic and Creative Problem-Solving.

H_{05} There is no significant difference between student's responses on interest, before and after teaching mathematics using (1) Analytic method(2) Creative Problem-Solving and (3) conventional lecture method.

1.6 Basic Assumption

The following were the basic assumptions for the study. In carrying out this study it was assumed that;

¡. The students used for the study have covered the Senior Secondary (SS2), Mathematics ` Curriculum that were familiar with four (4) topics in mathematics.

1.7 Significance of the Study

Mathematics is useful for day to day activities particularly in our homes and industries and also an important tool for science and technology development; hence the result is significant for the following reasons.

The study will help authors to advocate appropriate methods of teaching mathematics concept in their textbooks in subsequent editions. The findings will help in improving further education, since more students will be able to read course of their choices. The finding will be useful for further researchers in Analytic and Creative Problem-Solving.

Performance and interest as well as other theories of learning. The findings could be used to clarify, support or substantiate the existing learning theories expressed by other psychologist. It

could contribute to the improvement of Mathematics teaching and learning at all levels of secondary schools. It could foster new approaches in curriculum and text development. It could help in actively involving the participation of students. Also, Mathematics being the backbone of science and technology is a prerequisite for almost all engineering and other technological courses. It is therefore anticipated that the findings of this study would be valuable to various bodies/stakeholder that are likely to benefit from the outcome/result of the study, and those who are engaged in scientific and technological policy formulation, implementation and development in the country like: teachers, students, universities and colleges, National educational organization and curriculum developers. In addition, the study will help teachers in the adaption of appropriate approach of teaching mathematics concepts Analytic and Creative problem-solving problem skills. Teachers responsible for the teaching of Mathematics to secondary school students might utilize the finding in the secondary school classroom by:

1. Helping students to have conception shift in favor of mathematics valid concept.

2. Taking into consideration, students prior knowledge and

3. Developing inexpensive modules that would enhance teaching, learning and assessing understanding of mathematics concept. Furthermore, it is hoped that the study would encourage students to be actively involved in the construction of knowledge and to take charge of their own learning. Active participation of student might help them to develop self-confidence and positive interest toward Mathematics.

Additionally, institutions of higher learning where Mathematics teachers are trained would need to /incorporate the approaches to teaching learning. This would enable them produce more efficient teachers who would help student construct knowledge on their own. Bodies like Mathematical Association of Nigeria (MAN) Statistics Association of Nigeria (SAN), National

Education Research and Development Council (NERDC) that carry out researches discuss and disseminate research findings, might wish to consider the result of the research with a view to using the Analytic and Creative problem-solving to promote mathematics instruction in schools. Again, the findings of the study would be useful to mathematics textbooks publishers as it will assist them in selecting materials and activity questions base exercises to be incorporated in the text that would promote academic performance and change interest positively among students. Finally, poor attitude acquired at the foundation level could continue to hurt the students at every level of education. This trend if left to continue, will in no small measure affect adversely the growing needs to have trained scientist, technicians, economist and people in other fields of profession, since all depends in one way or the other upon Mathematics. The findings of this study is hoped to change negative interest towards mathematics concept among secondary school students.

1.8 Scope/Delimitation of the Study

This study examined the effect of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Secondary School Students, Sabon-Gari Local Govt Kaduna State. Nigeria. It covered selected public Senior Secondary Schools in Sabon-Gari Local Government (SS2) that are under Sabon-Gari Educational Zone. The SS2 were used because they are the most appropriated sets. SS1 were newly admitted, while SS3 students were getting ready for their Senior Secondary Certificate Examination (SSCE). The study considers the effect of Analytic and Creative Problem-Solving approach on Interest and Performance in Mathematics among Secondary School Students. The topics taught were from syllabus of SS2 are as follows.

Also the concepts taught in mathematics during this study included Quadratic equation, Simultaneous equation, Sets and Surds at the confine of the SS11 curriculum. These Concepts

were chosen because knowledge of them establishes the foundational background leading to mathematics among Senior Secondary Schools. The concept is also part of the SS11 curriculum. These topics were selected for the purpose of this research because they involved concepts that required active participation by the students and teachers at SS11 level during the teaching and learning process, with the assumption that they may sound a bit abstract to students at the Senior Secondary School level. In addition, the Analytic and Creative problem-solving performance test was the instrument used consisting of 20 items with option A –D. Also the mathematics concept statement questionnaire was used to find out interest of student towards mathematics before and after the treatment.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

The main purpose of the study was to investigate the Effects of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Secondary School Student. The review enabled the researcher to know what previous researchers have found out on topic relating to the present study for better organization and understanding. The literature was reviewed under the following Subheadings:

2.2 Theoretical Framework on Analytic Problem Solving;

2.3 Analytic Problem Solving;

2.4 Analytic Problem Solving, Reasoning in a Classroom Environment;

2.5 Analytic Problem Solving Progress Monitoring;

2.6 Theoretical Framework on Creative Problem Solving;

2.7 The Concept of Creativity in Education

2.8 The Creative Problem Solving;

2.9 General Intellectual Abilities

2.10 General Creativity and Mathematical Creative Problem Solving.

2.11 Implication of the Literature Reviewed on the Study

2.2 Theoretical Framework on Analytic Problem Solving

This study's theoretical framework was Analytic method. Each perspective provides a specific focus for the analytic lens, I use to make sense of the data and to arrive at specific and general findings. In what follows, I discuss the notions of critical events, inscriptions, contents of mathematical experience, and inter-locution. I end with a discussion of what can be called researcher as a participant interlocutor. Maher's notion of critical events for the past fifteen years, Maher (2002) have lead a longitudinal research program, one that is unique in the field of mathematics education. Observational studies such as these one have played a central methodological role. Indeed, studies that identify, trace, analyze, and theorize about

the development of mathematical ideas under particular conditions by individual learners as they work collaboratively in small groups have been the raison d'être of the research directed by Maher in which her colleagues and students have participated.

From this research program, important analytic tools and theoretical notions have been developed. Gathered data, particularly video clip were used to aid inquiry into the moment-by-moment thinking of learners as evidenced in transcripts of their verbal interactions among themselves and with teacher-researchers and in records of their inscriptions. In their studies, Maher and her collaborators (Powell, Francisco, & Maher, 2001) initiate analyses by identifying particular instances in the mathematical work of learners termed critical events. They posit an event as a connected sequence of learners' utterances and other actions. An event is called criticalwhen it demonstrates a significant or contrasting change from previous understanding, a conceptual leap from earlier understanding, or a cognitive obstacle (Steencken, 2001 Kiczek, 2000; Maher, 2002;).

By connecting sequences of critical events and further analyzing them, for example, by constant comparisons (Glaser & Strauss, 1967), researchers build narratives that initially are amalgams of hypotheses and interpretations and that in turn influence subsequent identification and analyses of critical events. In this sense, critical events and narratives emerge together. Critical events were contextual. The critics of an event are in the eye of the beholding researcher. An event that may be considered critical to one observer may not be considered as such by another observer. Given a particular set of data, events identified as critical depend on specification of the study. A critical event is a designation that depends on the subject of a researcher's inquiry. Thus, an instance in which learners present a mathematical explanation or argument may be significant for a research question concerned with learners' building mathematical justifications or proofs and, as such, will be identified as

a critical event. Similarly, a researcher concerned with the influence of teacher interventions on learners' reflective abstraction or mathematical understanding might deem as critical those events that connect teacher questions and to specific oral, written, or gestic articulation of learners' thinking. Moreover, the relation between critical events and research questions pursued also imply that researchers might identify events as critical that include instances of cognitive obstacles somehow significant to their study. Finally, an event may be deemed critical that is unrelated to the a prioritheoretical or analytic concern of a researcher but that nevertheless signals his or her attention. Whether resulting from an a priori or a posterioriperspective, the identification of an event as critical, therefore, rests on researcher criteria. Following Steencken (2001), who in her study explicates criteria for selecting events as critical, mathematical experience suggested by Gattegno (2001), I indicate criteria for this study that I use for determining a critical event. Importantly, critical events can be affective or cognitive moments in which learners pursue lines of thinking that depart from those privileged in school or academic mathematics. In describing the role of critical events in data analysis, Maher (2002) states the following: The analysis begins with the identification of critical events. The mathematical content of each critical event is identified and described, taking into account the context in which the event appears, the identifiable student's approaches and/or heuristics employed earlier evidence for the origin of the idea, and subsequent mathematical developments that follow its emergence. Critical events are temporally related to other events. Episodes of critical events, whether in expected or unexpected directions, are typically striking, connected to prior events, and prefigure upcoming events. As Maher states, "Each critical event defines a timeline, consisting of a past, a present and a future" and presents the following diagram (2002,) in Figure 2:

Past_____present_____future_____ (critical event)

Figure 2. Temporal relationship among a critical event and its antecedent and descendant events.

Realizing the temporal position of critical events, therefore, alerts researchers to examine their antecedent events as well as their influence on later understanding as well as to trace the development of ideas manifest in the critical event. Furthermore, when studying, for instance, the development of mathematical ideas or the growth of mathematical understanding, a critical event is associated to a time line and researchers may need to look for other related events in the past and in the future. Collections of somehow related critical events can be theoretically and analytically important. Besides being temporally related, a critical event may be thematically related to other events. If the related events are critical and lead to growth in understanding, then the set of critical events form what Kiczek (2000) defines as a pivotal strand or a pivotal mathematical strand(Steencken, 2001). Within a narrative such strands emerge and point to the mathematical ideas and forms of reasoning that learners develop that are key in building a learner's mathematical understanding. Analytically, I would add, it is important to name the pivotal event, thereby indicating what narrative theme to which it belongs. Moreover, when analyzing the discursive interaction of learners, a critical event that qualitatively changes their inquiry trajectory, I coin as a watershed critical event. Such an event is often preceded by a series of related critical events that can be collected together as pivotal strand to indicate a discursive thread that begets the watershed critical event. In turn, the watershed initiates a cascade of events some of which may be critical.

Inscriptions are special instances of the more general semiotic category of signs. A sign is an utterance, gesture, or mark by which a thought, command, or wish is expressed. A sign expresses something and, therefore, is meaningful and as such communicative, at the very least, to its producer and, perhaps, to others. However, its meaning is not static. A sign's denotation and connotation are subject to modification in the course of its discursive use. As a

discursive entity, a sign is a linguistic unit that has two, connected components. Saussure (1983) proposes that a sign is the unification of the phonic substance that we know as a "word" or signifierand the conceptual material that it stands for or signified. He conceptualizes the linguistic sign (say, the written formation) as representing both the set of noises (the pronunciation or sound image) one utters for it and the meaning (the concept or idea) one attributes to it (Saussure, 1983). Thus, sign = signifier + signified. Saussure observes further that a linguistic sign is arbitrary. A sign being the unity of signifier and signified implies that both components are arbitrary (Saussure, 1983). The signifier is arbitrary since there is no inherent link between the formation and pronunciation of a word and what it indexes. A monkey is calledmacaco in Portuguese and le singe in French, and further in English the animal is denoted "monkey" and not "telephone" or anything else. Just as the signifier is arbitrary so too is the signified. This can be understood in the sense that not every linguistic community chooses to make salient by assigning a formation and a sound image to some aspect of the experiential world, a piece of social or perceptual reality. Consider, for example, the signified cursor, mauve, and zero. They index ideas that not all linguistic communities choose to lexicalize. This is a significant point about Saussure's observation of the arbitrariness signs. I will return to this issue after making a point about the relationship between sign and meaning. Sfard (2000) argues that a sign is constitutive rather than representational since meaning is not only presented in the sign but also comes into existence through the it. Specifically, she states that mathematical discourse and its objects are mutually constitutive: It is the discursive activity, including its continuous production of symbols, that creates the need for mathematical objects; and these are mathematical objects (or rather the object-mediated use of symbols) that, in turn, influences the discourse and pushes it into new directions. (Original emphasis). Mathematical signs—objects, relations, register, talk, and so on—are components of mathematical discourse and are intertwined in

constituting mathematical meanings. Signs exit in many different forms, and inscriptions are but one. What are inscriptions? Inscriptions are written signs. They are produced for personal or public consumption and for an admixture of purposes: to discover, investigate, or communicate ideas. As other researchers and mathematics educators (Dörfler, 2000; Lehrer, Schauble, Carpenter, & Penner, 2000; Speiser et al, 2002) emphasize, building and discussing inscriptions are essential to building and communicating mathematical and scientific concepts. In a discussion of mathematics and science teaching, Lehrer, Schauble, Carpenter, and Penner (2000) illustrate how learners work "in a world of inscriptions, so that, over time, the natural and inscribed worlds become mutually articulated" and the importance of a "shared history of inscription".

In mathematics, the invention, application, and modification of appropriate symbols to express and extend id`eas are constitutive activities in the history of mathematics (Struik, 1967). Saussure's theorization about signs and their arbitrariness is applicable to inscriptions. For mathematics education the arbitrariness of signifieds is a more significant point about Saussure's observation concerning the arbitrariness signs. The conceptual material that one lexicalizes with, for example, marks on paper indicates what one sees, one's insight into material reality or the reality of one's mind. In research on mathematics education, participants' inscriptions open windows on their thinking. Their inscriptions present ideas they choose to lexicalize or symbolize. By analyzing inscriptions, researchers can infer participants' thinking. As Speiser, Walter and Maher (in press) underscore, what counts as mathematical in analyzing inscriptions is not the inscription itself, which are "tools or artifacts, but rather how the students have chosen to work" with their inscriptions. The importance of inscriptions for learners is that they invent or appropriate them. In so doing, they change their relationship to what the inscription signifies and, as such, turn abstract ideas into concrete ones. On the issue of the concrete and abstract nature of objects, Wilensky

(1991), arguing for a "revaluation of the concrete," states the following: concreteness is not a property of an object, but rather a property of a person's relationship to an object…Concepts that were hopelessly abstract at one time can become concrete for us if we get into the "right relationship" with time.…The more connections we make between an object and other objects, the more concrete it becomes for us…the more ways we have of interacting with it, the more concrete. (Original emphasis) As shall be shown in the next section, other researchers echo Wilensky's theoretical position on the concreteness or, by implication, the abstractness of a mathematical object.

2.3 Analytic Problem-Solving

As noted earlier, Analytic Problem-Solving thinking approach is necessary when an ambiguous situation requires the learner to identify or create a problem to solve. It involves the reasoning process described above, but involves a further element of inquiry, often in situations with less well-defined parameters and outcomes. This skill is required when a learner faces an often ill-defined, more global problem. Here's a typical school situation students might face when they realize that a test is coming up: What do I study and how I do know what is important?" Perhaps an assignment is given such as, "Write a persuasive essay that describes why one of two Internet search engines is better." Before one can apply one's reasoning skills, it is critical that there is a clear idea of what it is that needs to be reasoned. Is there a difference in search engine usefulness or does the student need to discuss technical issues; what does the teacher mean by better? Where the problem is not clear, the approach required is one of inquiry, and to inquire is to question. Questioning combined with reasoning, thus, is the key to Analytic thinking. In John Dewey's words (1986), "Thinking is inquiry, investigation, turning over, probing or delving into, so as to find something new or to see what is already known in a different light. In short, it is questioning." Even a simple instance of ambiguity, for example, a student reading a novel is confused when the author

likens a character to an historical figure. The inquiring reader wonders questions and now has a problem to solve. Questions in classroom reading comprehension exercises generally are presented following a prose reading. Students are to “test their understanding” of the text with the questions. Unfortunately, this approach is based on a rather passive view of how one learns from text. Active, meaningful, responding must be verified if we are to ascertain that the activity leads to learning (Markle, 1990). Brethower’s (in Heiman, 1990) observation of successful college students found that they:

• Ask questions of new materials, engaging in a covert dialogue with the author or listener, forming hypotheses, reading or listening for confirmation;

• Identify the component parts of complex principles and ideas, breaking down major tasks into smaller units;

• Devise informal feedback mechanisms to assess their own progress in learning; and

• Focus on instructional objectives, identifying and directing their study behaviors to meet course objectives.

• Simply reading text cannot be considered active nor does it exemplify meaningful responding. When questions are posed after text is read, students must often reread the text to find the answers and become engaged in the act of answering, rather than being engaged in an act of discovery or inquiry.

Conversely, orienting questions, provided by the text or a teacher, and presented prior to the reading task, may serve a different function. They may tap prior knowledge, facilitate recognizing important passages while reading, and provide a basis for feedback as to whether or not the text is understood (Osman & Hannafin, 1994).

Another system of question-generating instruction is derived from the work of Dale Brethower at the University of Michigan in the 1960s who, in turn, refined the SQ3R (Survey, Question, Read Recite, Review) techniques originally designed by Robinson (1946) and revised by Fox (1962). This "Learning to Learn" system (Heiman & Slomianko, 1985) has resulted in significantly improved grades and retention through graduation and is the only college-level program certified by the U.S. Department of Education as producing such gains (LTL site). The Learning to Learn (LTL) system has been further refined by Robbins, Layng, and Jackson (1995) into a program known as *Fluent Thinking Skills.* Whereas the TAPS procedures prepare students for the final three observations of the four described by Brethower, the first, questioning, must be taught separately and added to the learner's repertoire to produce a true analytic thinker. Teaching students how to question, therefore, has become a central part of the Morning side program. Students learn to question in a variety of contexts and this skill is later combined with the problem solving skills that have been acquired and practiced through our TAPS program. Several approaches are used to teach questioning.

Flesch (1951) in "The Art of Clear Thinking" advocates strongly for this exercise, "And that's why, if you're interested in producing ideas, the Greek yes-or-no game is useless, while the game of twenty questions is the ideal model". To shape up better question generating, the students collect all questions generated and rate them after the solution has been attained. This exercise helps students apply a questioning approach in a non-textual environment. The primary approach for teaching Analytic thinking in our content courses is the Fluent Thinking Skillsprogram. The program consists of a series of systematically designed instructional sequences and practice exercises that teach different types of questioning, and then provides considerable guided practice in their application. Once the questioning skill is firmly in place, students are taught to apply it to textual material they are to learn. Students are asked to first

generate questions to textual material without first fully reading it. They base their questions on the headings, sub-headings, initial sentences in a paragraph, captions, etc. Once the questions are posed, the students are asked to answer them prior to reading the text. One of the critical features of the Fluent Thinking Skillsprogram is that each student must find each discrepancy between the answer to the self-posed question and the response request specified within the text (or lecture material). Figure 2 shows the work of a middle school student using the Fluent Thinking Skills approach with a science text. Each learner creates and identifies a unique discrepancy based upon individual experience. This requirement of self-questioning and finding the discrepancy between what the learner initially calls the "Best Guess" and what the text provides as the answer is labeled, "Not match," and defines what the learner needs to learn. It is the comparison of what the learner knows prior to reading and after reading that defines the discrepancy. The reading-to- answer-questions approach targets exactly that which is missing from the learner's repertoire. Students are encouraged to apply their

TAPS skills to first answer their question, and then to resolve the discrepancy. The production of the student notes in Figure 2 begins in a TAPS partnered environment with the Problem Solver scanning the textbook headings to preview the chapter.

Problem Solver*:* I see the name of this chapter is Protist and Fungi. The first heading on this page says Reproduction, sexual and asexual.

Active Listener:Yeah, good idea to tie the chapter title with the heading.

Problem Solver:I need to anticipate how the author will talk about reproduction. The words sexual and asexual are almost the same, so it seems like a compare and contrast question will work well. (Inspecting the problem space)

Active Listener*:* Sounds right.

Problem Solver*:* (writing question in margin) "Compare and contrast asexually and sexually reproduction to protist

Active Listener:Check your question – I don't think it's a complete sentence.

Problem Solver:Oh, I'll cross out the ly. Thanks for following along. And now I'll make my Best Guess.

Active Listener:Nice. Let's see what the book says. Problem Solver reads passage and identifies that the discrepancy must include the discussion of parent and makes a comparison statement and contrast statement. Once students have mastered this process, other approaches are added such as using charts and graphs to see relationships in the subject being studied, finding sameness in related concepts, and extending relations to areas outside of what is being studied, among others. What has emerged is a general rule: we learn through discrepancies and we extend what we know through samenesses (cf. Skinner, 1957). One is based upon the familiar game of 20 questions and is known as the Suchman Inquiry Approach (after Suchman, 1966). After students read or hear a short mystery or puzzling scenario, they generate questions that are answered by the teacher with an answer that is either yes or no.

2.4 Analytic Problem Solving, Reasoning and Thinking in a Classroom Environment

Today's Morning side classroom integrates instruction in effective problem solving, reasoning, and Analytic Problem Solving thinking, drawing primarily from the investigation of problem solving processes pioneered by Dewey (1933), Bloom (1950), Skinner (1957, 1969), Samson (1975) who credits Albert Upton's methods of 1933, Whimbey (1975), Markle and Droege (1980), Heiman and Slomianko (1988), (Markle, 1990), Whimbey, Lochhead (1991) and (Tiemann & Markle, 1991), Robbins, Layng, and Jackson (1995), and

Robbins (1996). The analysis of learning outcomes combined with instruction founded on sound design principles empowers educators to teach the most complex of cognitive skills.

At Morning side Academy, a small private laboratory school, the faculty fully believes and works toward the radical notion that intelligence can be taught, that intelligence is neither static nor determined at birth (see Whimbey, 1975). That students should be skilled problem solvers, reasons, and analytic thinkers is not in dispute. Most educators agree that teaching students to be good analytic problem solving thinkers is important and that rote memorization, although having value, must augment not replace, the ability to problem solve on one's own. However, there is no consensus about how to teach these skills. A longitudinal study was conducted at McMaster University, by Donald Woods, a professor in the Department of Chemical Engineering, (Woods, 1998) to investigate approaches of teaching analytic problem solving. The study provides evidence that three approaches often used to teach analytic problem solving don't work. To summarize from the McMaster report [italicized text not in original]:

Ineffective approach #1: Give students open-ended problems to solve.This approach is ineffective because the students get little feedback about the process steps, they tend to reinforce bad habits, they do not know what processes they should be using and they resort to trying to collect sample solutions and match past memorized sample solutions to new problem situations.

Ineffective approach #2: Show students how you solve problems by working many problems on the board and handing out many sample solutions.This, we now see, is ineffective because teachers know too much. Teachers demonstrate "exercise solving". Teachers do not make mistakes; they do not struggle to figure out what the problem really is. They work forwards, not backwards from the goal. They do not demonstrate the "problem solving" process; they

demonstrate the “exercise solving” process. If they did demonstrate “problem solving” with all its mistakes and trials, the students would brand the teacher as incompetent. We know; we tried!

Ineffective approach #3: Have students solve problems on the board; Different students use different approaches to solving problems; what works for one won’t work for others. When we used this method/approach as a research tool, the students reported “we learned nothing to help us solve problems by watching Jim, Sue, and Brad solve those problems! “

Many teachers will recognize these approaches. Whereas the goal of creating good problem solvers seems to be shared by nearly everyone, there is less clarity about how to achieve the goal. However, there are some promising approaches, one of which is the McMaster Problem Solving Program. This program improves the problem solving, reasoning, and analytic thinking skills of college students. Almost all successful approaches (as described by Gustafson and Pederson, 1985, Heimann and Slomianko, 1988; Whimbey and Lochhead, 1991) share two characteristics, 1) they are relatively unknown, and 2) they were developed for high school age students and above. This paper will summarize some of the effective approaches that can help a teacher shape the qualities described by Whimbey and Loch-head, and how the author and her colleagues at Morningside Academy and elsewhere, have designed effective programs to teach these vital problem-solving, reasoning, and thinking skills to children much younger than college students. At any given time, the Morningside Academy population may include students with special needs. Experts in the field of teaching problem solving and thinking skills have remarked that certain procedures are reserved for students of particular intellectual or academic ability level. For example, Beyer (1997) describes one of the limitations of thinking aloud, which many problems solving approaches advocate, stating that thinking aloud may be “difficult for students, especially for younger

ones and some of those considered to be academically at risk". Experts in the field of gifted education offer their cautions as well. LeStorti (2000) maintains that developing thinking

Skills for gifted children present special challenges. However, Morning side Academy faculty members employ the same instructional and motivational procedures to develop problem solving, reasoning, and thinking skills with all students. We have found that explicit research-based instruction leads to eager, inquisitive, and masterful learners of all ages and levels of achievement. Our school provides a training and observation setting for professionals around the world to witness evidence-based practices.

Skinner (1969) describes that Analytic Problem-Solving proposes that, "two stages are easily identified in a typical problem." He describes the first stage of problem solving as, "the situation for which a response has not previously been reinforced, and the second stage as the process of solution, that is, "the behavior which brings about the change is the problem solving and the response to it is the solution." Whereas the stages may be easily identified, Skinner also points out the ubiquitous nature of Analytic Problem-Solving. "Since there is probably no behavioral process which is not relevant to the solving of some problem, an exhaustive analysis of techniques would coincide with an analysis of behavior as a whole. Accordingly, numerous definitions of Analytic Problem-Solving have been proposed. In an instructional environment, the Analytic Problem-Solvingto which I refer is defined as a behavioral sequence, in a situation of defined parameters, which leads to a defined outcome as stated by an instructor, within a text, or by the learner. This type of problem solving is to be distinguished from Analytic Problem-Solving thinking. Analytic problem solving thinking is a similar behavioral sequence, but involves a further element of inquiry and situations with less well-defined parameters and outcomes. Analytic problem solving thinking is necessary when an ambiguous situation requires the learner to identify or create a problem to solve. Reasoning, an essential element of both problem solving and analytic problem solving

thinking, involves the manipulation of verbal stimuli to restrict response alternatives in accord with a problem's outcome. That is, when the environment requires a learner to produce verbal stimuli that sequentially and systematically make one pattern of behavior more likely than another in order to meet a contingency requirement, reasoning is defined. This process is akin to what Skinner (1969) described as an "inspection of reinforcement contingencies" such that behavior can be described that meets contingency requirements without direct contingency shaping or rules. Procedures have been developed that train learners in reasoning and in the inspection of the requirements for reinforcement in most problem solving situations.

This study was disagree Woods (1998) investigation, that stated it's was provides three evidences approaches that often used to teach Analytic problem-solving don't work. To summarize from the McMaster report [italicized text not in original]: the Ineffective approaches are in page 27/28.

Based on Sani (2020). Effects of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Secondary School Student. Sabon-Gari Kaduna state, Nigeria. Both approaches (Analytic and Creative Problem-Solving) was effective, base on his findings.

2.5 Analytic Problem Solving Progress Monitoring

We employ many explicit approaches in teaching basic skills (reading, writing, mathematics) and content courses (e.g. history, science, cultures and geography) in addition to explicitly teaching reasoning and thinking skills. Given that our school was founded in 1980, with more than 30 years of revising our procedures and instituting annual curricula changes, a discussion of the full Morning side Model of Generative Instruction is beyond the scope of this paper (for an extend discussion see, Johnson and Street, 2004). The most widely referenced

methodologies are the use of self-monitoring with a Precision Teaching approach, which builds both confidence and skills as students set and attain personal academic goals, and Direct Instruction (as well as "direct instruction"). Placement in classes with homogeneous grouping and ongoing progress monitoring all contribute to academic gains.

The data collected as students develop their TAPS skills have included duration time to practice and acquire thinking vocabulary words and phrases, as well as time to accurately complete a variety of increasingly complex exercises from "teacher store" workbooks over the course of the school year. These data are used to maintain homogeneous groups during the dedicated TAPS instruction. Similarly, the acquisition of Fluent Thinking Skills includes practice and frequency building exercises in discriminating, creating, and answering questions. Morningside students routinely make vast improvements in their year over year academic performance (Johnson & Street, 1994). Though we do not have data that parses the effects of our various procedures, we can see our learners change from being withdrawn, reluctant, tentative, or careless upon admission to our school, and exhibiting "Subject Matter Unapproached Tendencies" (Mager, 1997), to eager problem solvers who enjoy tackling and solving problems through questioning and reasoning. By directly instructing our learners in these analytic problem solving, analytic problem solving thinking, and reasoning repertoires, and by creating a culture of thinking and inquiry, we are demonstrating the power of our behavior analytic to produce learners who will be able to face and solve the rapidly changing problems of the 21st century.

2.6 Theoretical Framework on Creative Problem-Solving.

I based the theoretical framework of this study on Amabile's (1983) social psychology and the componential conceptualization of creativity theory. Stressed that the production of "creative" responses and works required domain-relevant skills, creativity-relevant skills, and task motivation. Domain-relevant skills consisted of information from the domain, including facts, knowledge, principles, and technical skills to solve the problems in that domain. Certainly, creativity was unlikely in a domain of which the subject had limited knowledge. Amabile (1983) stated that even if one had extraordinary domain-relevant skills, she might still fail to produce creative response or works in the absence of creativity-relevant skills. Thus, both domain-relevant and creativity-relevant skills have been fundamental to creating novel products in heuristic tasks. Also, Milgram and Hong (2009) found that both domain general and domain specific creative thinking were main components of the creativity, and using either of them alone to assess creativity was not sufficient.

Amabile (1983) listed the following thinking styles involved in creativity-relevant skills: (a) breaking perceptual and cognitive sets to leave old thinking habits and to think differently; (b) understanding complexity; (c) having as many response options as possible; (d) suspending judgment to avoid eliminating a creative idea that might look ordinary at first; (e) using broad categories when thinking, to be able to identify relationships between ideas; (f) remembering detailed information; and (g) perceiving creatively to be able to identify fresh ideas and different solutions.

1 Domain-Relevant Skills Include (a) Knowledge about the domain (b) Technical skills required (c) Special domain-relevant "talent" Depend on (d) Innate cognitive abilities (e) Innate perceptual and motor skills (f) Formal and informal education

2 Creativity Relevant Skills include (a) Appropriate cognitive style (b) Implicit or explicit knowledge of heuristics for generating novel ideas (c) Conducive work style Depend on (d) Training (e) Experience in idea generation (f) Personality characteristics

3 Task Motivation Includes (a) Attitudes toward the task (b) Perceptions of own motivation for undertaking the task Depends on (c) Initial level of intrinsic motivation toward the task (d) Presence or absence of salient extrinsic constraints In the social environment (e) Individual ability to cognitively minimize extrinsic constraints

Components of creative performance (Amabile, 1983). Finally, Amabile (1996) proposed that task motivation was the determinant of the difference between what one cando and what one willdo in creative performance. What one can docould be defined by the level of domain relevant and creativity relevant skills. However, in addition to those skills, task motivation was required to define what one will do. Lacking intrinsic motivation, those capable of producing creative work in problem solving may fail to do so. Domain relevant skills, creativity relevant skills, and task motivation can appear in students' products in different ways, including the ability to produce as many solutions as possible to a given problem, the variety of approaches used, and the novelty in the products created (Amabile, 1996).

Current instruments have been insufficient to distinguish the bright from the truly gifted because these instruments were designed only to detect students who produce a higher number of correct solutions rather than more creative products (Guilford, 1967; Baska, 2008). However, in order to assess creative problem solving that involved domain-relevant skills, creativity-relevant skills, and task motivation an instrument should include items to examine the use of creative problem solving and the novelty in products along with the number solutions provided.

2.6.1 Analyzing the Studies

The low quality of research has led to a fundamental lack of empirical evidence in the social sciences, and this has been a major criticism in social sciences for decades. In 2005, Odom, Brantlinger, Gersten, Horner, Thompson, and Harris, (2005) published an article to address this criticism. They employed a scientific approach to develop a set of criteria that a study should meet to be of high quality, and then specified these criteria for certain research designs: experimental and quasi-experimental, qualitative, correlational, and single subject. Considering the designs of the studies I selected for reviewing the literature, I adapted the quality indicators presented by Thompson, Diamond, McWilliam, and Snyder (2005) for correlational research and by Gersten, Fuchs, Compton, Coyne, Greenwood, and Innocenta (2005) for experimental and quasi-experimental research. As a final step, I analyzed the studies based on the following criteria: (a) relevant information about participants, (b) appropriate selection and use of data analysis, and (c) the existence of validity and reliability data for the measures used in the research. I then rated the articles based on a three-point scale for each of the quality indicators. The numbers in the ratings represented the following meanings: 3 - the researcher(s) of the study provided all the information needed, 2 - more information was needed in minor content, and 1- more information was needed in major content. Also, for some of the studies I used a .5 point to indicate that although the information that was needed (i.e., participants' \ demographic background) was not provided, the researchers still included some supplementary information (e.g., schools' entire populations' general (demographics). The ratings of the studies have been presented. All of the studies except one (Tabach & Friedlander, 2012) were designed based on quantitative approaches.

However, among all the studies some researchers examined mathematical creativity using correlational designs (Han, 2000; Livne & Milgram, 2006; Hwang, Chen, Dung, & Yang, 2007; Kuo, Maker, Su, & Hu, 2010; Bahar & Maker, 2011; Baran, Erdogan, & Cakmak, 2011;

Lin & Cho, 2011; Pitta-Pantazi, Sophocleous, & Christou, 2012; Tan, Mourgues, Bolden, & Grigorenko, 2013), while others used comparative designs (Coxbill, Chamberlin, & Weatherford, 2013. Based on the quality rating, the reseacher examined common strengths and weaknesses across all the studies.

The authors of the seven studies (Mann, 2005, Livne & Milgram, 2006; Bahar & Maker, 2011; Baran et al., (2011); Lin & Cho; (2011), Bahar, 2013.) provided all the necessary information, including participants' age or grade span, gender, and demographic backgrounds. In three of the studies, the demographic backgrounds of the participants were not stated; however, some other information was provided such as free or reduced lunch rate of the school, or participants' disability statuses. Finally, eight of the studies (Kattou et al., 2013; Leikin & Lev, 2013; Pitta-Pantazi et al., 2013; Tan et al., 2013) lacked either gender or demographic background information. The most common strength across all the studies was that all of the researchers linked their data analysis techniques to the research questions and appropriate unit of analysis.

The researchers of twelve of the studies (Han, 2000; Mann, 2005; Livne & Milgram, 2006; Bahar & Maker, 2011; Lin & Cho, 2011;, Pitta-Pantazi et al., 2012; Tabach & Friedlander, 2012; Bahar, 2013; Coxbill et al. 2013; Tan et al., 2013) linked their analyses directly to their research questions or hypotheses.

Although in seven of the studies (Kim et al., 2003; Kwon et al., 2006; Hwang et al., 2007; Kuo et al., 2010, Baran et al., 2011; Kattou et al., 2013; Leikin & Lev, 2013) the analyses were not explicitly linked to the research questions or hypotheses, the studies were still organized enough to allow the reader to establish the link between the analyses and the research questions. All studies involved assessing creative problem solving in mathematics or mathematical creativity as part of their methodology. Therefore, choosing an appropriate measure for research questions has been a major phenomenon in this line of research, and this

was another common strength across all the studies. The researchers of the sixteen studies (Bahar, 2013; Bahar & Maker, Kattou et al., 2013; Leikin & Lev, 2013.) selected appropriate measures that were designed specifically for assessing mathematical creativity. However, in four of the studies (Coxbill et al., 2013 Tan et al., 2013), the researchers selected measurement tools that either consisted of problems that were chosen from a pool (not specifically designed), or activities that might change from one application to another. The most common weakness across all the studies was the missing information when reporting the validity of the measurement tools used in the studies

Out of all nineteen studies, only in five of them (Kim et al., 2003; Bahar & Maker, 2011; (Tabach & Friedlander, 2012; Leikin & Lev, 2013; Bahar, 2013; Pitta-Pantazi et al., 2013) were the exact validity coefficients reported. Even though the researchers of the other fourteen studies stated that the instruments used in the studies were valid, lacking the exact validity coefficients decreased the quality of the studies. The researchers of seventeen studies reported the exact reliability coefficients. Although two of the studies (Leikin & Lev, 2013) were missing the exact values for reliability, they still provided the information that the instruments were reliable. Overall the studies analyzed in this chapter to review the literature ranged from high to average quality. However, all of the researchers provided sufficient information to

Qualify for the analysis conducted in this chapter.

2.6.2. Findings of the Studies

The studies were analyzed using both qualitative and quantitative strategies based on the following themes: (a) the criteria used to calculate mathematical Creative Problem-Solving scores, (b) the relationship between creativity in mathematical problem solving and general creativity, (c) the relationship between creativity in mathematical problem solving and mathematical achievement, and (d) closed vs. open ended approach when identifying creativity

in mathematical problem solving. Was designed to provide brief information about the purposes, participants, instruments, and results of the studies analyzed in this chapter to review the literature. The criteria for the scoring s. The researchers of the ten of the studies (Mann, 2005, Kwon, Park, & Park, 2006; Bahar & Maker, 2011 ;Lin & Cho, 2011; Pitta-Pantazi, Sophocleous, & Christou, 2012; Kattou, Kontoyianni, Pitta-Pantazi &Christou, 2013; Kim, Cho & Ahn, Leikin & Lev, 2013; Tabach & Friedlander, 2013) stated that their criteria for measuring mathematical Creative Problem-Solving or mathematical Creativity consisted of fluency, flexibility, and originality.

Guilford (1967), who defined fluency as the number of correct answers, flexibility as the number of different types or categories of answers, and originality (novelty) as the exceptionality, or rarity of the answers. Although fluency, flexibility, and originality were mainly used to measure mathematical creativity, a few of these researchers also added some other components such as elaboration (Kim, Cho & Ahn, 2003 Bahar & Maker, 2011), problem solving correctness (Leikin & Lev, 2013) to measure mathematical creativity. Also a small number of researchers preferred to develop their own criteria to analyze the creativity in mathematics rather than using fluency, flexibility, and originality.

2.7 The Concept of Creativity in Education

Creativity has to do with thinking, exploring and discovering new facts and principles, which can be found in science, music and the arts (Guilford, 1959). Creativity is the initiative that one manifest by his/her power to break away from the usual sequence of thoughts and his expression is usually referred to as creative dimension or patterns which include fluency, flexibility, originality and motivation (Akinboye, 1977). Science educators recognize the need for developing creativity in the learners which should serve as the most valued educational outcome as students will develop the skills of fluency, flexibility, originality and motivation.

On creativity and academic achievement, Olorukooba and Lawal (2007) maintained that guided discovery improved academic performance and influenced creativity traits of fluency, flexibility, originality and motivation in students. Since science education aimed at making conscious effort towards making provision for educational experiences that will encourage creative effort in the learners' .There is the need to use various methods of teaching that will aid learning and creativity in students. The skills employed in problem-solving teaching method such as manipulative skills, evaluation, logical reasoning, self-confidence and flexibility in thinking can assist the learners to be creative if monitored and properly implemented in science teaching.

Ausubel (1960) in support of use of lecture method observed that when concepts are presented meaningfully, learners apply them to solve problems and create new ideas that aid to solve puzzles. Thus, lecture method could aid in creating new ideas and originality in thinking and thus enhance creativity. Problem-solving teaching method is one of the activity-based instructional methods that have been employed using certain skills such as manipulative skills, logical reasoning ability and creative thinking (Adesoji, 2008). Problem-solving teaching method has been reported to developed self-confidence, team spirit and creative thinking in learners. The Generating Ideas component includes the generating of options in answer to an open-ended or invitational statement of the problem. This component has only one stage called Idea-Finding. During the diverging phase of this stage, the person or group produces many options (fluent thinking), a variety of possible options (Flexible thinking), novel or unusual options (original thinking), or a number of detailed or refined options (elaborative thinking). The converging phase of Idea-Finding provides an opportunity for examining, reviewing, clustering, and selecting promising options. Although this stage includes a converging phase, its primary emphasis is divergent. The Planning for Action component of CPS is appropriate when a person or group recognized a number of interesting

or promising options that may not necessarily be useful, valuable or valid without extended effort and productive thinking. The need may be to make or develop effective choices, or prepare for successful implementation and social acceptance. The two approaches included in the component are called Solution-Finding and Acceptance-Finding. During the Solution-Finding stage of CPS, promising options may be analyzed, refined or developed. If there are many options the emphasis may be compressing or condensing them so that they are more manageable. If there are only a few promising options, the challenge may be to strengthen each as much as possible. There may be a need to rank or prioritize a number of possible options. Specific criteria may be generated and selected upon which to evaluate and develop promising options or select from a larger pool of available alternatives. Although there may be some divergent thinking in this stage, the emphasis is primarily convergent. The Acceptance-Finding stage of CPS involves searching several potential sources of assistance and resistance for possible solutions. The aim is to help prepare an option or alternative for improved acceptance and value. This stage helps the problem solver identify ways to make the best possible use of assistance and avoid or overcome possible sources of resistance. From considering these factors, a plan of action is developed and evaluated for implementation. Although the primary emphasis of CPS is within the process dimension of creativity, it is most fruitful to also consider the people who are using the process, the situation or environment within which it is being used, and the nature of the product or outcome of the problem-solving efforts. Isaksen, Puccio & Treffinger (1993) have referred to this as taking an ecological approach to CPS.

Although CPS can be taught and learned, it is best suited for the solution of real-life problems requiring creativity. Renzulli (1982) identified a set of parameters for determining whether or not a problem was “real”. He asserted that since a real problem involves an emotional or effective commitment as well as an intellectual or cognitive one, it must have a personal

frame of reference. Second, it must not have an already existing solution. Third, merely naming something a "real" problem does not necessarily make it so for a particular individual or group. Finally, the purpose of a "real" problem is to contribute something new or bring about some sort of change to the sciences, the arts or the humanities. Thus, there may be a continuum from unreal, realistic, to real kinds of problems. Isaksen & Treffinger (1985) identified a parallel concept of ownership as important for selecting challenges for CPS. Ownership can occur on a variety of levels, including those that are like sole proprietorship's, partnerships and corporations. For example, challenges owned by a single individual are like sole proprietorship's. Other challenges may have corporate or global ownership and be shared with others. Ownership for a challenge means that the problem solver has some degree of influence, authority, and decision-making responsibility for implementing the solutions. It also means that the problem owner is motivated and willing to submit the challenge to systematic problem-solving efforts and is interested in following through on the results. Finally, in order for someone to have ownership in a challenge for CPS, there must be a deliberate and explicit search for something new. In short, in order for ownership to exist, there must be influence, interest and imagination. Defining CPS this way offers an important extension to most standard academic conceptions of problem solving. In particular, this extends Raaheim's (1985) orientation to problem solving relying on utilizing past knowledge and experience to close the current gap or decrease ambiguity in the present. The emphasis on reconciling the present with the past ignores the potential importance of the future. An anticipatory goal state that focuses thinking toward a possible and desired future can be a powerful motivator and initiative for human problem solving. Raaheim, like a few other scholars, opposes the very concept of creative problem solving, suggesting that if the task is entirely novel, the only appropriate approach is trial and error.

This position ignores the wealth of information from introspective and biographical accounts that indicate the importance of intuition generally, in the sciences (Eyring, 1959), in art (Polanyi, 1981), in basic research (Selye, 1988), and in mathematics and psychology (Garder & Nemirovsky, 1991). This is an important issue from a practical point of view in light of recent evidence that managerial decision making in new task environments calls upon intuition (Blattberg & Hoch, 1990; Mitchell & Beach, 1990; Taggart & Valenzi, 1990) and despite challenges presented to a rationally oriented information processing model of cognition (Russ, 1993).

Simply dumping the construct of creative problem solving off the deep end of trial and error is inconsistent with the argument that Schank and Childers (1964) put forth regarding the importance of asking questions about new tasks to actively construct explanations and generalizations. In fact, they suggested that by acknowledging the existence of scripts, the key to creative thinking is making an analogical leap to recall another event explained in a similar way. Similar arguments for the existence and importance of this analogical kind of thinking have been called bisociation (Koestler, 1964), Janusian (Rothenberg, 1971), and the magic synthesis (Arieti, 1976). Finally, Boden (1991) dismissed trial and error as a reasonable explanation for creativity by asserting that these random kinds of mental processes generally produce only first time curiosities, rarely radical surprises that account for major discoveries, inventions and creative works.

In addition, the nature of the tasks within the research paradigm proposed by Raaheim (1971) may not really have a good fit with a more creative mode of problem solving. The tasks used in research following this approach (Raaheim & Kaufmann, 1972; Kaufmann & Raaheim, 1973; Raaheim, & Kaufmann, 1979; Raaheim, Kaufmann & Bengtsson, 1980) may be unfamiliar, but they also lack the features of interest and influence.

There is also a strong theme in the creativity literature that supports the use of the unfamiliar

to provide insight and bring novelty into a task (Koestler, 1964). The emphasis on using the past to adjust intelligently to the present misses another important aspect of creativity. These insights are not necessarily produced by trial and error. Gardner & Nemirovsky (1991) described thematic components that operate tacitly to provide generative schemes for learning, thinking and creative work. These robust frameworks function as "unarticulated intuition" in guiding the creator's thinking in a variety of content domains. Rather than being outside of present knowledge and thinking power, creativity in problem solving extends the threshold of efforts to understand human adjustment and change. We can now find a rightful place for the opportunity focus that the future image can provide. The future may provide a powerful "pull" for problem solving. CPS can also provide a practical framework from which to examine possible tasks and mental activity, as well as an applied research context for studying different kind of mental representations and activities.

Creativity is the capacity of persons to produce compositions, produce ideas of any sort which are essentially novel add previously unknown to the producer (Adeyanju, 1996).He continued that creativity could be imaginative activity or through syntheses or may involve the framing of new patterns and combination of information derived from past experience and the transplanting of old experience and relationships to new situations. Based on the above learners need to connect the present situation with the past experience in order to arrive at something if not new but unknown which is the focus of creativity. Akinboye (2001) sees creativity as a means of enabling humans to get most out of experiences and resoueses.it focuses on the process of forming original ideas through exploration and discovery. In line with Akinboye (2001) Creative human can be defined experimentally as a fellow who has a higher score in open-ended test than intelligence tests. This is not to say that creative individual is not intelligent. It only means that if given an open-ended testand an intelligence test, the creative individual will always score higher score in open-ended test than an

intelligence test. This implies that creative individual is divergent in thinking and production while intelligent individual is convergent in thinking and production.

Guildford (1959) looked at creativity as the initiative one manifest by his power to break away from the usual sequence of thoughts and this expression is usually referred to as creative dimension or patterns which included fluency, flexibility, originality and motivation. On why creativity skills are needed by learners Nwosu (1994) and Mari (2002) admitted that if the skills are well developed is capable of producing individuals who can take some responsibilities for shaping positively not only their own living but that of the society. Based on the above definitions and explanations on creativity skill scan be developed in learners through using activity-based instructional strategy such as discovery method, inquiry method and problem-solving teaching approaches among others. Since the methods and strategies give room for learners to work independently and the teacher facilitate the process of learning. Accordingly, Creativity therefore can be seen as the quality exhibited in arriving at unknown situation which is not necessary new and eventually lead to principles and inventions and so on. An individual that exhibited that quality is term a creative person and the way to arrive at the unknown is term creative process. He can also be referred to as a divergent thinker. Teachers seems to forgot that some students have creative potential that is left undeveloped or untapped, which is probably due to I don't care attitudes of the teachers, poor mastery of teaching methodologies and subject matter or teachers lack what qualities to reinforce in learners in the area of creative characteristics. Based on the above identifying a creative person and creative process will hopefully assist teachers towards developing creative potentials in learners.

2.7.1 The Concept of Creative Person

Manslow (1962) after studying several of his subjects determined that all people are creative, not in the sense of creating great works, but rather, creative in a universal sense that attributes a portion of creative talent to every person. Dodge (1991) opined that most educators do not expect students to produce new products characteristics of creative genius, it is appropriate if the work is appropriate to the task at hand and original within the student's ability. Michael (2000) admitted that to understand and predict a person's creative ability, two factors have often been considered which are intelligence and personality. **Intelligence** -In The development of creativity in the learners depends upon creative processes the results of which are new products. Sambo (2002) was of the opinion that it is that creative ability that raises humanity above the other living species in the world. He went on that creative abilities exist in varying degrees among humans, as do other kinds of intelligence. It is therefore a matter of getting those abilities to surface and making them to work for human development. On why some people reach a level of creative genius why others do not is still unknown. Trying to find out whether there is direct relationship between creativity and intelligence quotient (IQ). Torrance (1963) and Hayes (1990) submitted that there is no direct correlation between creativity and intelligence quotient (IQ).Edmund (1990) conducted a research using two-hundred and eighty-one randomly selected students from three different schools in Canada. The finding showed that IQ scores did not significantly correlate with creativity scores. Hayes (1990) submitted that creative performance may be better predicted by isolating and investigating personality traits **Personality** Traits-Researchers have shown that there are certain personality traits, associated with creative people (Wakili, 2007, Sambo, 2002, Hayes, 1990 and Stein, 1974).one of such list of traits as summarized by Devore, Horton and Lawson (1989) are:-

a. the ability to change undesirable habits into desirable ones.

b. A positive curiosity of the unknown.

c. A positive attitude towards new experiences

d. The ability to take negative criticism and term it into constructive action.

e. The ability to take risks fully knowing that his or her ideas may be attack by others

f. A good sense of humor.

g. The ability to make complex relationships between unrelated terms

h. The motivation to solve problem on their own.

i. High self-esteem and self-confidence in their abilities.

j. The ability to focus their full attention on a particular problem for an appropriate length of time The above listed are only a guide to help identify a person's creative potentials.

Manslow (1962) was of the view that all people are creative. On a research conducted to investigate the personality traits associate with the creative person, Runco, Nemiro and Walberg (1998) concluded that intrinsic motivation, problem finding and questioning skills were considered the most important trait in predicting and identifying creative achievement. Personality traits have been seen to help in understanding creative ability, but an important area of creativity theory lies in the identification of the creative processes. Problem-solving has been found to enhanced self-confidence (Danjuma,2005), logical thinking (Eze,2001) and discovery method one of activity-based method of instruction has been found useful in developing some of the personality trait associated with creative person (Wakili 2007).Most of this research reported are at Secondary School Level. This study is design to investigate the effect of problem-solving teaching method on self-efficacy, creativity and academic performance of NCE students' in genetics to see what the result will be.

2.7.2 The Creative Process in Education

Torrance (1963) sees Creativity is a combination of flexibility, originality and sensibility to ideas which enable the thinker to break away from usual sequences of thought into different and productive sequences the result of which gives satisfaction to him and possibly to others (Jones, 1971). From the above to combine flexibility and originality can only be possible using some creative process.

Creativity as a process that has been represented using various models. One of the earliest explanations of creative process was offered by (Wallas, 1926). His model consisted of four stages that are briefly described below:-

1. Preparation: - This is a stage where an individual identifies and investigate a problem from many angles.

2. Incubation: - At this stage an individual stops all conscious work related to the problems.

3. Illumination: - This stage is characterized by a sudden or immediate solution to the problem.

4. Verification: - This is the last stage at which time the solution is tested On the stereotype stage pattern Lytton (1970) opined that creative process is in five stages:-

¡ at first step the problem must be defined and important dimensions identified.

¡¡ Preparation: - here an individual saturates himself with as much as information pertaining to the problem as possible.

¡¡¡ Incubation: - At this stage problem-solving may be produced at the subconscious level. This can also be referring to as a period of withdrawal or meditation during which adequate time is given at the subconscious level to the problem at stake. For example music composers do withdraw just a poet.

¡V Illumination: - This is ended by a rapid insight or series of insights. This indicates that a solution has been arrived at.

V verification: - the final step is to test and critically evaluate the solution obtained during the stage of illumination. If the solution proves faulty, the thinker reverts to the stage of illumination.

From the above it could be infer that most creative products will go through stages of struggle. However, Stein Torrance (1966) and (1974) have added the communication stage to the creative process. This is where the new idea confined to one's mind is transformed into a verbal or non-verbal product. Based on the above a more comprehensive definition was deduce from the work of Torrance who viewed creativity as a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies and so on; identifying the difficult, searching for solutions, making guesses or formulating hypotheses about deficiencies, testing and retesting these hypotheses and possibly modifying and retesting them and finally communicating the result. Torrance definition resembles what some referred to as problem-solving. For example Savage and Terry (1990) generalizing from the work of several scholars, identified six (6) steps to the problem-solving process as below:-

Defining the problem: - Analyzing, gathering information and establishing limitations that will isolate and identify the needs or opportunities.

Developing alternative solutions:-Using principles, ideation and brainstorming to develop alternative ways to meet the opportunity or solve the problem.

Selecting a solution: - Selecting the most plausible solution by identifying, modifying and or combining ideas from the group of possible solution.

Implementing and evaluating the solution: - modeling, operating and assessing the effectiveness of the selected solution.

Redesigning the solution-incorporating improvements into the design of the solution that address needs identified during the evaluation phase.

Interpreting the solution: - Synthesizing and communicating the characteristics and operating parameters of the solution.

Comparing Graham's (1962) definition of creativity with Torrance's (1966) creative process, Lytton's (1970) creative process and Savage and Sterry (1990) problem-solving process, there are similarities between the descriptions. Guilford (1976) was of the opinion that problem-solving is creative. Based on the above it is expected that problem-solving teaching approaches may hopefully enhance creativity in learners. Creativity therefore can be seen as the result of creative process exhibited by the learners, leading to creative products which are useful and unknown to the public. Understanding creative process therefore will hopefully enhance the creative performance of the students leading to greater productivity and self-reliant. This study therefore is design to investigate the effect of problem-solving on self-efficacy, creativity and academic performance in genetics of NCE students' to see what the result will be.

2.7.3 Relationship between Problem-Solving and Creativity in Education

Creativity can be definedas influencing static knowledge by using dynamic intelligence. While Problem-solving is a form of knowledge which occurs as a result of assembling already known rules for the purpose of creating a new superior rule which is learn and allows appropriate solution to the problem (Gagne 1970).

Both Creativity and Problem-Solving are not only limited to a new product, but also to new processes. On the relationship between Creativity and Problem-Solving Dunckar (1945) submitted that the act of problem-solving involves reformulating the problem more creatively. Here the problem-solver must invent **a** new way to solve the problem by redefining the goals and approaching the final solution. In a related development Getzels & Csikszenthmihhalyi (1976) wrote that problem construction contributes to creative problem-solving and that is a predictor of real world creativity. While Guilford (1976) was of the opinion that problem-solving is creative. This may be because both involve use of some processes. This study is design to investigate the effect of problem-solving teaching method on self-efficacy, creativity and academic performance in genetics of NCE students' to see what the result will be.

2.8 The Creative Problem Solving

Isaksen and Treffinger (1985) expanded and refined the initial conceptualization of this model. For these researchers a problem can be “any important, open-ended, and ambiguous situation for which one wants and needs new options and a plan for carrying out successfully a solution”. According to Isaksen and Treffinger (1985) Creative Problem-Solving has six “stages” organized into the three components of understanding the problem, generating solution ideas, and planning for action by preparing and developing solutions for effective implementation. The six stages fall under these three components of Creative Problem-Solving and these are: mess-finding, data-finding, problem-finding, idea-finding, solution-finding, and acceptance-finding.The Creative Problem-Solving components (Isaksen, Dorval, & Treffinger, 1994). Understanding the problem encompasses stating a general, broad goal or a direction for problem solving (mess-finding), identifying important data and relevant facts (data-finding), and specifying a question to focus subsequent problem solving (problem-finding). Once the problem statement becomes available, the problem solver engages in idea generation during

which s/he generates options, reviews and selects promising alternatives (idea-finding). After several potential fruitful ideas are identified, the problem solver plans for further action by closely evaluating the promising options to refine them (solution-finding). Finally, the problem solver specifies potential sources of assistance and resistance for the possible solutions. These could be any individuals, places, materials, and things that can either support or hinder further planning actions and implementation of a potential solution (acceptance-finding). The CPS framework is not a simple, step-by-step model in which the problem solver runs through the six stages rather the CPS framework "provides a structured set of operations or tools as resources upon which the problem solver draws as needed" (Treffinger, 1995). Thus, the problem solving process is flexible and dynamic and is based on a task appraisal in which the problem solver "deliberately assesses the intended outcomes, the people, the situation, the methods available, and the techniques to be used.This model originates from the work of Osborn (2006) who was invested in promoting creativity in individuals and groups in order to support their ability to find new and useful solutions.

2.8.1 The Simplex Creative Model.

The basic premise is that two mini processes namely ideation and evaluation occur in the three phases of creative thinking. According to Basadur, Runco, and Vega (2000) individual, team, and organizational creativity is a continuous, dynamic, circular 3-phase process of finding problems, solving them and implementing successfully new solutions that can potentially lead to the discovery of additional novel and useful problems. Ideation and evaluation occur within each of the three phases of the Simplex creative model. Ideation or active divergence is defined as "the generation of alternative ideas without evaluation" (Basadur et al., 2000).

On the other hand, evaluation, or active convergence is defined as the process of judging the generated ideas to select the most significant options. Idea generation is complemented by idea

evaluation, a two-step procedure during which ideas are evaluated for their relevance and appropriateness and their degree of originality (Runco & Chand, 1994). Four stages comprise the Simplex creative model: problem generation, problem formulation, problem solving, and solution implementation.

2.8.2 The Simplex Model of Creative Process.

The eight sub-processes under the four stages of the Simplex model are very similar to the six stages described in the Creative Problem Solving Framework. For example, problem and fact-finding in the Simplex model correspond to the mess-finding and data-finding in the CPS framework; and idea-21 finding and evaluate, select and plan in the Simplex model correspond to idea-finding and solution-finding in the CPS framework. The nuance in the Simplex model lies in the cycles of ideation and evaluation that occur in different phases of problem solving, although one could argue that they are evident as divergent and convergent thinking in the CPS framework. Mumford et al.'s (1991).Model of the creative process. A model of the cognitive processes involved in creative problem solving was proposed by Mumford, Mobley, Uhlman, Reiter-Palmon, and Doares (1991). Model of creative thought. In Mumford et al.'s (1991) model of creative thought, creative problem solving begins when an individual encounters a novel, ill-structured situation and attempts to define the problem at hand. In order to construct the problem, learners may need to search through multiple problem representations and use anumber of them to understand the problem and identify goals, procedures, information and constraints (Reiter-Palmon, Mumford, O' Connor Boes, & Runco, 1997). The new problem representation that emerges from combining and reorganizing the above elements guides the search for relevant information, and the individual eventually identifies and selects categories or concepts that can be applied in the specified situation. The categories are combined and reorganized to produce new ideas (understandings of the problem), which are then evaluated. Based on the idea evaluation process, an idea or a set of ideas are implemented and the

effectiveness of idea implementation is monitored (Mumford, Baughman, & Sager, 2003). The creative process model permits recursive processing between the eight cores processes involved in creative thinking: 1) problem construction, 2) information encoding, 3) category selection, 4) conceptual combination, 5) idea generation, 6) idea evaluation, 7) implementation planning, and 8) solution monitoring (Blair & Mumford, 2007).

2.8.3 A Comparison of the Creative Problem Solving Models

The models presented above to describe the creative problem solving process have several common cognitive components. The process is initiated with problem construction which includes identifying the existence of a problem and defining an ambiguous situation into a workable problem by developing a mental representation of the situation. The problem construction stage precedes the idea generation stage in CPS models in which the problem solver produces multiple solution ideas. Idea generation is an integral part of the CPS models. However, in Wallas' (1926) and Mumford et al.'s (1991) models there is an intermediate cognitive process in which ideas are associated and integrated before the problem solver generates solution idea(s). Such conceptual combination gives "rise to new concepts which provide a basis for subsequent idea generation" (Mumford, Blair, & Marcy, 2006). In all models but Wallas's the problem solver generates alternative solution ideas and selects an idea by applying a set of evaluation standards. In Wallas's model the problem solver experiences an illuminative distinct "aha moment" in which s/he is struck by an insight resulting in the creative solution.

Idea evaluation is a common metacognitive component of CPS models as they all share a component that allows the evaluation of the most promising and potentially fruitful solution idea. Idea evaluation in models of CPS involves the appraisal of the formulated idea based on a set of standards that influence the acceptance and successful implementation of the idea within

a setting, domain, or field (Csikszentmihalyi, 1999). Idea evaluation as conceptualized in a model proposed by Mumford, Lonergan and Scott (2002) consists of three sub processes: (a) forecasting the outcomes of idea implementation; (b) appraising the solution idea with respect to a set of standards, and (c) revising ideas based on the task requirements and the implementation context (Lonergan et al., 2004). Idea evaluation begins with forecasting the potential outcomes and the consequences of implementing an idea within a specific context. Forecasting relies on the perceived task requirements, the goals of problem solving, and the set of standards that the problem solver establishes in order to judge the solution. Appraisal of the solution is based on a set of standards, and the process of appraising the solution informs decision making on whether the idea should be implemented as it is, revised or abandoned. Eventually the problem solver may revise the solution based on the standards and the implementation context before the idea gets implemented. In some instances, the problem solver generates new ideas if forecasting suggests that problems are expected to arise when the solution is implemented or if the appraisal is not satisfactory.

Despite the fact that all the models present evaluation as a cognitive operation that comes post-idea generation to evaluate the chosen solution, some form of evaluative thinking occurs while the solution is formulated. Empirical support was found in a study conducted by Lubart (cited in Lubart, 2000) who prompted participants to evaluate their work as they composed short stories and made still life drawings. The researcher had systematically manipulated the timing of the evaluations, the number of the evaluations and the evaluation prompt. The results showed that for the writing task, the timing of self-evaluation had a significant effect on the creativity of the outcome. The participants who evaluated their ideas earlier in the process had higher average creativity score than those who evaluated their work later or who were prompted to evaluate throughout the task. Further research is needed to determine whether evaluative thinking has a more prominent cognitive monitoring role during CPS rather than

only being a closure process for judging a solution. Other metacognitive processes in the CPS models besides solution evaluation include planning and solution monitoring. Traditionally, planning is defined as the process by which the problem solver decides which method to devise to solve the problem (Mayer & Wittrock, 2006) and it is described as process planning in Isaksen and Treffinger's CPS framework.

Moreover, monitoring the implementation of a solution is another metacognitive aspect associated with the application rather than the generation of a creative solution and it closes the loop of the CPS process in the model proposed by Mumford et al. (1991). In summary, problem construction, idea generation and idea evaluation are the integral cognitive components of creative problem solving models. In the section that follows, I will discuss the degree to which ISPS and CPS present two distinct forms of problem solving by comparing (a) the goalsof each problem solving activity and (b) the cognitive componentsof the two processes.

2.8.4 Looking Beyond the Problem Solving Paradigms

The primary goal in creative problem solving is to develop solutions that are original and effective so that they address the goals and comply with the constraints of a problem situation. The models of creative problem solving aim to provide an explanation of the process that leads to develop effective and original solutions. However, to what extent does the requirement for novelty that characterizes creative problem solving differentiates this cognitive process from problem solving? Two components of creative problem solving have been proposed by creativity researchers to be unique descriptors of the creative problem solving process. First, researchers argue that creative problem solving is a distinct form of problem solving because in CPS, problem construction is based on multiple activated representations (Mumford et al., 1991). In fact, the problem solver moves across alternative representations of the problem and searches these multiple activated problem spaces in order to identify the goals, key

information, procedures to solve the problem and the relevant constraints that will form a new problem representation. Second, creativity researchers propose that creative problem solving is a distinct form of problem solving due to the process by which ideas are integrated. Association of concepts permits the generation of several ideas from which a creative solution emerges (Weisberg, 2006).

Sinnott (1989) has even argued that the generation of possible solutions is a creative exercisethat is made possible by bridges of associations between the problem spaces and is informed by the problem solver's epistemic beliefs of what counts as a valid solution. Finally, in the two aforementioned models of ISPS the problem solver selects a solution for which she was able to construct a persuasive argument. Thus, one can reasonably argue that creative problem solving is a form of problem solving manifested in ill-structured problems, which call for an original and effective solution. Despite the fact that creativity researchers argue that the nature of problem construction, conceptual combination and idea generation in CPS differentiate it from ISPS, these processes are very similar to those in ISPS models. Searching through multiple problem spaces, integrating ideas and generating various solution ideas are elements of the ill-structured problem solving process as it is conceptualized in Sinnott's (1989) and Jonassen's (1997) ISPS model. Both Sinnott and Jonassen highlight that the most important part of ISPS is to identify the appropriate problem space among the multiple competing representations.

The creative problem solving process as it is conceptualized in the four models of creative problem solving and especially the models proposed by Wallas and by Mumford and colleagues has similar cognitive elements with Sinnott's Model for Solution of Ill-structured Problems (1989) and Jonassen's Instructional Design Model (1997). The advantage of the two CPS models is that they simulate a problem solving process that allows recursive, circular thinking in comparison to stage models of ISPS that represent the problem solving process as

one-step-at-a-time serial-processing activity (e.g., Jonassen's Design Theory of Problem Solving). Thus, the study of the effects of argumentation scaffolds in creative problem solving is theoretically framed based on the model of the creative process proposed by Mumford and his colleagues (2003) because it allows recursive thinking while the problem solver attempts to develop an original and effective solution to an ill-structured problem, and because the researchers have proposed a model that explains idea evaluation, which is the focus of the present empirical study.

What has contributed in the development of the creative problem solving research as a different paradigm is the impact of the work of Guilford (1956) on the Structure of the Intellect and the work of Torrance with respect to the development of the Torrance's Test of Creative Thinking (1986). Both theorists argued that creativity involves divergent thinking. Divergent thinking is defined as the ability to generate various ideas and is assessed using four indicators: fluency (number of ideas), flexibility (number of different types ideas), originality (uncommon ideas) and elaboration (enrichment of ideas).

Both Guilford (1950) and Torrance (1988) argued that divergent thinking is an indicator of creativity and idea generation is a basic cognitive component of creative problem solving. Thus, researchers who examined creative problem solving have traditionally included in their designs independent variables such as divergent thinking, intelligence, and personality type and less often measures of domain knowledge. This research approach has resulted in a relatively general, domain independent creative problem solving paradigm (Diakidoy & Constantinou, 2001). However, the ability to generate a large number of ideas does not ensure that the solutions will be innovative and effective. In fact, Weisberg (2006) argued that the domain-specific knowledge and domain relevant strategic knowledge that individuals bring to a problem, allows them to incorporate, elaborate, and extend their knowledge in order to develop creative breakthroughs. In the upcoming section I will present and compare the

variables (e.g., cognitive, metacognitive, and affective), which were found to predict or be associated with ISPS and CPS, in order to explore whether there is a set of unique variables that contribute in solving problems which require original and effective solutions.

2.9 General Intellectual Abilities

Intelligence was found to predict the quality and originality of solutions as well as the quality of the creative problem solving process such as the construction of a representation, encoding of information, integration of ideas and generation of new ideas (Mumford et al., 1996; Reiter-Palmon et al., 1997; Mumford et al., 1997). Researchers who examine creative problem solving typically measure two general intellectual variables including intelligence and divergent thinking. Intelligence was conceptualized as fluid intelligence and it was typically operationalized as students' verbal reasoning ability (Sternberg & O' Hara, 1999). However, divergent thinking was found to be a stronger predictor of the quality of solutions proposed to creative problems in comparison to verbal reasoning (Mumford et al., 1997). Several studies indicated that divergent thinking has positive effects on the degree of originality and quality of solutions (Reiter-Palmon, et al., 1997; Diakidoy & Constantinou, 2001; Osburn & Mumford, 2006;; Hunter, et al., 2008; Reiter-Palmon, 2009). Divergent thinking is defined as the ability to generate numerous varied ideas (Runco, 2007). Four indices have been used to operationalize divergent thinking: fluency, originality, flexibility, and elaboration. However, researchers typically score participants' responses to creative problem solving tasks for fluency (i.e., the number of responses generated) because fluency scores have positive relations with other divergent thinking indices such as flexibility and originality. The tasks that are typically administered to assess divergent thinking are either verbal or figural and ask participants to generate unusual uses for objects (e.g., uses of a brick), instances of concepts (e.g., round things), consequences to hypothetical events (e.g., people did not need to sleep), and similarities between concepts, Such divergent thinking tasks capture the ability to generate

varied responses but they have been criticized for their usefulness as indicators of creative thinking since fluency is not sufficient for the development of creative ideas (Weisberg, 2006). Solving problems within a domain requires domain-specific expertise because the facts, concepts, principles and cognitive processes that characterize a domain are critical for one to be able to produce original and effective solutions.

2.9.1 Knowledge Variables Domain and Structural Knowledge

Domain specific knowledge guides the search of critical relevant information (Voss & Post, 1988). In fact, evidence in a study of problem solving in the domain of basketball showed that undergraduates with rich domain-specific knowledge searched for relevant information, represented the problem more comprehensively, and performed better in ill-structured problems in comparison to novices (Devine & Kozlowski, 1995). Knowledge of important facts and concepts referred to as declarative knowledge, as well as knowledge of concepts and principles in a domain and the way concepts are related and organized are positive predictors of ISPS performance. Individuals with high levels of knowledge were found to perform better in ISPS. For example, Osana, Tucker & Bennet (2003) in a study of social studies decision making problems found that high school students used their knowledge about the concept of equity to make decisions about how to distribute scholarship funds.

Not only the breadth of domain knowledge but also the organization of concepts is a predictor of ISPS performance. Shin, Jonassen, and McGee (2003) found that middle schoolers' knowledge of astronomy concepts and an understanding of their relations predicted problem solving performance and transfer in astronomy. Interestingly, applying more than one type of knowledge organization structures has the potential to facilitate the production of more creative solutions. In a study conducted by Hunter et al. (2008) the researchers prompted undergraduate students to use multiple knowledge structures (i.e., schema, associations, and cases). In this

case, they found that the activation of schema or associations with case-based knowledge resulted in solutions that were of higher quality and originality in comparison with the solutions proposed by individuals who were prompted to use only a single knowledge organizational pattern.

Well organized and integrated knowledge is important to both CPS and ISPS. Additional evidence for this is provided by studies which examined the effects of structure supports that facilitated students in organizing their knowledge. For example, Chen and Bradshaw (2007) examined the effects of knowledge integration prompts in comparison to prompts which supported the problem solving process, and they found that the knowledge integration prompts improved problem representation, monitoring and evaluation of a solution and contributed to higher overall problem solving performance. In general, well integrated domain knowledge makes processing more flexible as organized knowledge is more readily retrievable and integrated knowledge contributes in more strategic processing.

2.9.2 Approach Knowledge.

Approach knowledge is defined by Alexander, Schallert, and Hare (1991) as the awareness of "a process or procedure that permits the completion of a given cognitive task". 29 Several domain general strategies that contribute to CPS performance have been identified in the literature including means end-analysis, decomposition into subproblems, conversion into another problem more readily solved, and hypothesis testing (Jonassen, 1997; Voss & Means, 1989). Specifically, Mumford and colleagues found that problem solvers use metaphor which is another type of analogy as a search strategy to identify connections between knowledge

structures when the relations are more abstract and the knowledge structures are more diverse (Mumford, Baughman, Maher, Costanza, & Supinski, 1997). In creative problem solving the use of analogy is critical for the generation of new ideas through the combination and reorganization of structural knowledge. The use of analogy as a mechanism for creating an innovative idea is based on the process of mapping in which the problem solver "uses systematic connections between the sources and target to generate plausible, although fallible inferences about the target" (Holyoak, 2004).

Domain specific approaches are stronger predictors of problem solving performance than the aforementioned general approaches. Strategic knowledge is acquired via experiences which provide opportunities to use and organize information within a domain (Voss et al., 1983). Examples of domain specific strategies include historical analysis conducted in international relations problems (Voss et al., 1991), analysis of causal factors accounting for students' behavioral problems (Hew & Knapczyk, 2007), and proactive action in platoon leadership problems (Schunn, McGregor, & Saner, 2005). What distinguishes experts from novices in terms of their strategic knowledge is not the number of strategies that they have available in their repertoire but rather the selection of approaches. When experts' strategic knowledge was examined by Schunn and colleagues (2005) they found that experts in platoon leadership neither knew more approaches nor used more strategies to solve problems in comparison to novices. Rather, experts were more effective in selecting approaches based on the features of a situation and by taking into consideration the overall success of the approaches in previous problem situations they dealt with. Strategy selection by experts is more effective for two reasons: 1) experts focus on germane, relevant, and contradictory contextual information both qualitative and quantitative in order to construct the problem space and 2) experts develop patterns of organization based on the problem context, which are easily retrievable when experts encounter similar problems.

According to Voss and colleagues (1983) the patterns of knowledge organization developed by the experts' application of approaches are similar to the procedural knowledge in Anderson's ACT model because experts apply strategic knowledge as a set of procedures to solve particular problems.

2.10 General Creativity and Mathematical Creative Problem Solving.

Creative thinkers are known by their ability to notice details and differences that other individuals ignore (Milgram & Hong, 2009).Therefore the level of their domain-general creative thinking has affected their domain-specific creative thinking when generating and solving problems (Milgram & Hong, 2009). In this subtheme, I analyzed nine different studies (Bahar, 2013; Baran, Erdogan, & Cakmak, 2011; Leikin & Lev, 2013; Lin &Cho, 2011; Tan; 2013) to examine the relationship between general creativity and mathematical creative problem solving ability.Eight of the studies (Bahar, 2013; Tan; 2013) were correlational and one of them (Hwang, Chen, Dung, & Yang, 2007) was comparative. In all eight of the correlational studies, researchers used different instruments to assess mathematical creativity, and either all (i.e., Math Creative Problem Solving Ability Test) or most of the items (i.e., DISCOVER Math) in these instruments were open-ended problems or tasks. In eight of the studies (Bahar, 2013; Leikin & Lev, 2013; Tan; 2013) detailed descriptions of the content of the instruments and the evaluation criteria used to measure mathematical creativity were provided.

Although Baran et al. (2011) described the content of the test they used, they did not specify the evaluation criteria for the test. The relationship between mathematical creativity and general creativity by analyzing the findings of these nine studies. The researchers of five of the studies (Livne & Milgram, 2006; Lin & Cho, 2011; Bahar, 2013; Leikin & Lev, 2013; Tan, 2013) found significant positive correlations between mathematical creativity and general creativity with r-values.

However, the researchers of three of the studies (Han, 2000; Kuo et al., 2010) did not find any significant correlations between these two variables. Also in one of the studies (Hwang et al., 2010) only one component of creativity, elaboration was found to be significantly correlated with creative performance in mathematics. When analyzed these relationships further, I discovered that all of the studies in which significant relationships were found (Lin & Cho, 2011; Bahar, 2013; Tan, 2013) between these two variables had participants who were in third or higher grade levels.

2.10.1 Mathematical Achievement and Mathematical Creative Problem Solving.

Students should be educated for their creative ability in a domain along with the training they receive for their knowledge and skills for the domain (Stokes, 2001). Therefore, analyzing the relationship among the students' mathematical knowledge, skills, and creative ability would enable educators to design a new path for increasing students' creative abilities and achievement levels simultaneously. In this subtheme were analyzed ten studies (Kim, Cho, & Ahn, 2003; Mann, 2005; Mann, 2009; Kuo et al., 2010; Tabach & Friedlander, 2012; Bahar, 2013; Bahar & Maker, 2011; Coxbill, Chamberlin, & Weatherford, 2013; Kattou, Kontoyianni, Pitta-Pantazi, & Christou, 2013; Tan et al., 2013) to determine the relationship between mathematical creativity and mathematical achievement.

All of the studies except one (Kim et al., 2003; Mann, 2005; Mann, 2009; Kuo et al., 2010; Bahar & Maker, 2011; Tabach & Friedlander, 2012) were conducted using quantitative approaches, more specifically correlational (Bahar, 2013; Kattou et al., 2013; Tan et al., 2013) or comparative (Coxbill et al. 2013) designs of the study that was conducted using qualitative analysis. The authors of all the studies provided detailed explanations about the instruments they used to assess mathematical creativity and mathematical achievement. Yet, only one of the studies in which the relationships among mathematical creativity, general creativity, and

mathematical achievement were examined, lacked the evaluation criteria used when scoring the mathematical creativity test.

Mathematical creativity and mathematical achievement were significantly correlated in all nine studies (Kim, Cho, & Ahn, 2003; Mann, 2005; Mann, 2009; Kuo et al., 2010; Tabach & Friedlander, 2012; Kattou, Kontoyianni, Pitta-Pantazi, & Christou, 2013; Bahar, 2013; Bahar & Maker, Tan et al., 2013). In fact, in six of the studies (Bahar & Maker, 2011; Kuo et al., 2010; Tan et al., 2013) the significance level of the correlation between mathematical creativity and mathematical achievement was lower than. Tan et al. (2013) used two different instruments to measure mathematical achievement when examining the relationship between mathematical creativity and mathematical achievement, and conducted two separate analyses using the results from both instruments. The correlation between these two variables was highly significant ($p < .001$) when MIDYIS (the math achievement instrument that has been used nationwide) was used in the analysis; however, the correlation between mathematical creativity and mathematical achievement was not statistically significant when mathematical achievement was assessed using the school wide test. I examined the studies to explore any relationship related to mathematical creativity and mathematical achievement. However, I did not detect any pattern between the grade levels of the participants and the relationships between mathematical creativity and mathematical achievement across the studies.

2.10.2 Open-ended problems and mathematical creative problem solving.

Kwon et al. (2006) used the open-ended approach as a program to develop divergent thinking while Bahar (2013) used it for identification and placement purposes. The researchers of both studies provided detailed descriptions of the instruments and the scoring rubrics used in their studies. Finally, in both studies, the use of openended problems when designing a program or an instrument resulted in a significant difference ($p < .01$ for both studies) in creativity.

Although all of the researchers of the studies analyzed in this section chose instruments that involved open-ended tasks or problems, only two of them (Bahar, 2013) specifically examined the effects of open-ended problems on mathematical creativity. Both studies were quantitative, however Bahar (2013) employed a correlational approach while used a comparative approach when analyzing the open-ended problems when used for measuring or cultivating students' mathematical creativity. Also,

2.11 Implication of the Literature Reviewed on the Study

Analytic and creative are structured approaches of teaching mathematics which results in students gaining knowledge of the principles and concepts of the subject. It also result in students having the ability to formulate and resolve problem as well as communicate and acquire other skills necessary for meaningful participation in life. Kurumeh, jimin and Mohammed, (2012) are of the view that in order to sustain the development of students performance and interest in mathematics, teachers could teach mathematics in application oriented form using appropriated approaches of Analytic and creative problem solving approach.

Students perception about science and mathematics and the role of teachers in the used of Analytic and creative problem solving approaches based classroom from that of the teachers in a conventional classroom. Researchers on the use of Analytic and Creative problem solving approaches, That focus on senior/junior secondary schools using pre-test and post tests for individual units making a direct comparison between two instructional approaches (Analytic and creative problem solving approaches) so as to find out which approach is more effective.

Some of the researchers have indicated that the female performed higher than male in some mathematics content, while others showed no difference between the male and female students. Some studies have revealed that male performed significantly better than their female

counterparts. Kurumeh, jimin and Mohammed, (2012), found that it's not possible sometime to use Analytic and creative problem solving in all situations particularly in large classes. Also, students could be frustrated if they cannot solve the problems themselves. Most researchers conducted on creative problem solving. Its effects on some variables gender, attitude. In this study, the two approaches of teaching, that is creative problem solving, would be corporate in to the teaching and learning of mathematics in SS2 class, so that it would improve the teaching and learning of mathematics in our schools, It's however, interesting to the note that these several studies were mostly done in other areas of mathematics not in senior secondary school. This study has been carried out in several science subjects make it feasible for it to be replicated, most especially in creative problem solving. However, the review encouraged and guided the researchers on study, the Effects of Analytic and Creative Problem-Solving on interest and performance in mathematics among senior school students in Sabon-Gari Kaduna.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The purpose of this Chapter was to describe the methodology of the study. Research methodology, according to Kothari (2004), is a way to systematically solve the research problem. And to examine the Effects of Analytic and Creative problem Solving (ACPS) on Interest and Performance in Mathematics among secondary school Students. In this chapter, presented under the following subheadings:

3.2 Research Design

3.3 Population of the Study

3.4 Sample and Sampling Techniques

3.5 Instrumentation

3.5.1 Validation of the Instrument

3.5.2 Pilot Study

3.5.3 Reliability of the Research Instruments

3.6 Administration of the Treatment

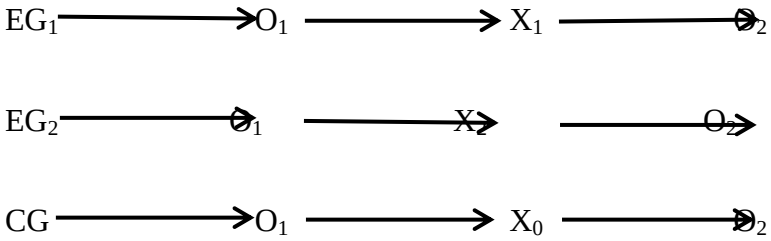
3.7 Data Collection Procedures

3.8 Procedures for Data Analyses

3.2 Research Design

The research design for this study was quasi-experimental research with pretest, post-test, experimental group and control group design. Both groups experimental (Analytic and Creative problem-solving) were given pretest and post-test and both experimental groups was exposed to treatment. While the control group was not exposed to treatment, but was only

exposed to pretest and post-test to see if there is significant difference in their performances and interest. The design of the study is illustrated as represented below;



KEY

Where: Experimental group (EG)

CG = control group

X_0 = traditional method

X_1 = treatment (AnalyticProblem-Solving)

X_2 = treatment (Creative Problem-Solving)

O_1 = pre-test, Interest Inventory

O_2 =post-test Interest Inventory

3.3 Population of the Study

The population of the study consisted of twelve (12) Senior Secondary School (SS2) students, at the government owned schools in Sabon-Gari Educational Zone of Kaduna State. (8) Schools ware mixed with male and female students. While three (3) schools were female only and one (1) school was only male students. That makes female students are more than the male population. With the total number of two thousand one hundred and forty two (2142),

where one thousand and sixty six (1066) were male and one thousand and seventy six (1076) were females shown as follows.

Table 3.3.1 Population of the Study

S/N	Name of school	Male	Female	Total
1	Government Secondary School Jama`a	102	48	150
2	Government Secondary School Bomo Zaria	28	22	50
3	Government Secondary School Kwangila	130	90	220
4	Government Secondary School Chindit	295	-	295
5	Government Secondary School Basawa	203	41	244
6	Government Secondary School Sakadadi	26	14	40
7	Government Secondary School Aminu	106	92	198
8	Government Secondary School Muchia	142	121	263
9	Government Girls Secondary School Chindit	-	205	205
10	Government Girls Secondary School D/Bauchi	-	205	205
11	Government Girls Secondary School Samaru	-	217	217
12	Government Commercial College Zaria	34	21	55
	Total	**1066**	**1076**	**2142**

Source: (Sabon Gari Education Zone 2017).

3.4 Sample and Sampling Techniques

Three (3) Senior Secondary Schools were randomly selected, using intact sampling techniques out of Twelve (12) Senior Secondary Schools, with the total number of one hundred and thirty (130) students, in line with Krejcie & Morgan (1970). Apart from the pragmatic reasons, sampling enables a researcher to estimate some unknown characteristics of the population and make generalizations (Zikmund, 2003). The probability sampling procedure that is given a known ensuring that the sample will be representative of the population (Keppel, 1991). The second is non-probability sampling which is arbitrary (non-random) and subjective (Cooper & Schindler, 2001). This study employed a probability sampling design. In this design, all SS2 students had an equal chance of being picked. Probability sampling ensures the law of Statistical Regularity which states that if on average the sample chosen was random one, the sample was have the same composition and characteristics as the universe (Kothari, 2004). The sample of this study was covered the total number of one hundred and thirty (130) SS2 mathematics students. The sample for the study comprised of three (3) senior secondary schools (SS2) that offered mathematics. Two of the selected schools were assigned as the Experimental groups (treatment) while the other one served as control groups. The intact sampling process was assigned by balloting to each experimental group and the other schools was control group as stated above.

Table 3.4.1: Sample for the Study.

Group	School	Male	Female	Total
Experimental 1 (Analytic problem-solving)		25	18	43
Experimental 2 (Creative problem-solving)		26	12	38
Control (conventional lecture method)		29	20	49
Total	**80**	**50**	**130**	

Source: adopted by the researcher, (2018).

The sampled schools were grouped into two experimental groups and one control group using intact sampling technique (use of balloting) by picking paper from the hat, involving rolling three (3) papers with code 01, 02, 03, representing the schools. In which code 01 and 02 are for the experimental groups (I and II) while 03 is for the control group.

3.5 Instrumentation

The instruments used for the study:

(1) Analytic Problem-Solving Performance Test (APT)

(2) Creative Problem-Solving Performance Test (CPT)

(3) Student Problem-Solving Interest Questionnaire (SPIQ)

Analytic and Creative Problem-Solving Performance Test.

Analytic and Creative problem-solving performance Test, The questions were set with objectives based on four of the six of Bloom's (1956) levels of cognitive learning domains. Bloom‟ hierarchy in cognitive learning domains taxonomy of thinking commonly referenced

by educators when discussing critical thinking it consist of 20 multiples choice objective questions with options drawn from the topic taught to the subject. The topic was quadratic equation, simultaneous equation, sets and surds. Students were required to choose the option that bears the correct answer to the question and the test was designed to last for a period of 40 minutes. This Table below contained questions sets across the content domain in order to test the students and had items measuring student's ability in knowledge, comprehension, and application indicated.

Table 3.5.0.1 Table of Specification

Content	**Knowledge**	**Comprehension**	**Application**	**Analysis**	**Total**
Quadratic equation	2	-	4	-	6 (30%)
Simultaneous equation	-	-	4	-	4 (20%)
Sets	5	1	-	-	6 (30%)
Surds	1	-	2	1	4 (20%)
Total	**8**	**1**	**10**	**1**	**20 (100%)**

These content were taught two experimental groups and control group. The two experimental groups received treatment taught using analytic and creative problem-solving, while control groups was not be exposed with treatment.

Student Problem-Solving Interest Questionnaire

Student Problem-Solving Interest Questionnaire. Were pre-tested and post-tested to determine responses of student's interest after exposed or taught using analytic and creative problem-solving. The instruments were adopted from kathryn (2006) by the researcher based on the previous study in student's interest toward mathematics. A questionnaire containing mainly closed-ended items was administered to 130 SS2 students randomly selected in each of the control and treatment groups. The responded questionnaires by the SS2 were separately

serially numbered for both experimental and control groups. The responses of students odd serially numbered were selected and used for analyses of the study. The opinion type questionnaire used a four point Scale ranging from: A= Agree (1), SA = Strongly Agree (2), D = Disagree (3), SD=Strongly Disagree (4), the items in the questionnaire were divided into the following two sections: Section A: Biographic characteristics of the respondents. Section B: Questions on student's previous knowledge and beliefs about the teaching of mathematics. The same questionnaire was administered (using the same group) in the post-test survey after the study to determine any changes the use of analytic and creative problem-solving approaches in teaching and learning mathematics, would increase students' performance .

3.5.1 Validation of the Instruments

The ContentValidation of Analytic Problem-Solving performance test (APT) Creative Problem-Solving performance test (CPT) and Students Problem-Solving Interest Questionnaire (SPIQ). Were assessed by expert that includes the following;

- Mathematics education lecturers not below Ph.D. status from science education, mathematics section, Ahmadu Bello University. Zaria.
- Teacher of mathematics in the selected Secondary School with BSc. Ed in mathematics.

These groups of experts were requested to critically examine the instruments to assure its correctness, clarity, appropriateness, readability and standard for SS2 students.

3.5.2 Pilot Study

The term pilot study refers as. To feasibility studies that are small scale versions, or trial runs, done in preparation for the major study (Pilot, Beck, & Hungler, 2001). one of the advantage of conducting a pilot study is that it might give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed method

or instruments are appropriate or too complicated (Van Teijlingen & Hundley, 2001). The instrument for the study, especially the questionnaires and the pre-test questions were first analyzed for consistency with the help of selected mathematics teacher in their school before they were piloted. Government secondary school shika was selected for the pilot testing with the numbers of participated students sixty (60) from SS2. The pilot study school was not involved in the research study. From the feedback obtained after piloting, the study instrument was defined.

3.5.2.1 Treatment and Control Procedures

According to Campbell and Stanley (1963), pre-test and post-test comparisons provide robust assessment of a pedagogical intervention by detecting possible changes before or after treatment. Control and treatment groups were used for this study. Three (3) out of the twelve (12) schools was selected using intact sampling (was assigned by balloting to each experimental group and the other schools was for control group). Each school was assigned to the control group and the treatment (experimental group). The control group was taught by their teachers using the conventional teaching method approach, while the treatment groups (experimental) were taught by the trained teachers using Analytic and Creative Problem-Solving.

Each of the groups was tested before treatment (pre-test). After they were taught for six weeks, the two groups (experimental) were again tested (post-test). The results of pre-test and post-test were compared to provide robust assessment of a pedagogical intervention by detecting possible changes after treatment.

In addition to the above design, learners in both control and experimental groups were observed while they engaged in learning. Also, the both groups were administered a researcher self-prepared questionnaire to answer. According to Kothari (2004), the principle of

randomization provides protection, when an experiment is conducted against the effect of extraneous factors by randomization. Kothari (2004) stated that the principle indicates that the variation that may be caused by extraneous factors can all be combined under the general heading of chance. By applying this principle we can have a better estimate of the experimental error (Kothari, 2004).

3.5.3 Reliability of the Research Instrument

The instruments of analytic and creative problem-solving performance test and the student problem-solving interest questionnaire were pilot tested to determine their reliability. The test retest method was employed for Analytic and Creative Problem-Solving Performance test and result analyzed using PPMC calculated to be 0.95, while student problem-solving interest questionnaire split half method was used and the reliability were 0.86 using Cronbach Alpha.

3.6 Administration of the Instrument(Treatment)

The two groups: Two experiments and control all took the pretest, post-test. Control group were not exposed with treatment (problem-solving approach). The tests were administrated by the researcher and one assistant. For each test, the researcher explains to the students the content of the test and instructs them to do all rough work in the answer sheet and cross it out. He appealed to them to have sense of responsibility and register their sincere reaction. They were assured that the research will benefit not only themselves but also their school. Lastly the researcher assured the students that their responses will be kept in confidence and that it has nothing to do with their examination results either at present or in future.

3.7 Data Collection Procedure

After teaching the both experiment (Analytic and Creative Problem-Solving) and control group for 6 weeks. The experimental 1 (Analytic Problem-Solving) was post-tested using

Analytic Problem-Solving performance test (APT), experimental2 (Creative Problem-Solving) was post-tested using Creative Problem-Solving performance test (CPT) and Students Problem-Solving interest questionnaire (SPIQ) were assigned to both experimental and control group. The both experimental and control groups were post-tested using the same instrument used in pre-test, to asses their performances. Their scripts were marked and the score were calculated and recorded based on both experiments and control group according to their ability level as well as male and female.

3.8 Procedure for Data Analysis

The collected data was analyzed and used to answer the research questions and test the stated hypotheses in chapter one, at p≤0.05 level of significant as follows.

¡. There is no significant difference between academic performance of students taught using Analytic and Creative problem-solving, the nature of the data collected was interval, the groups was independent related, mean, and standard deviation for descriptive and the statistical tool used for analyses was t-test.

¡¡. There is no significant difference between academic performance of students taught using Analytic problem-solving and those taught using conventional lecture method, Interval data was collected, the groups was independent related, mean, and standard deviation for descriptive and the statistical tool used for analyses was t-test.

¡¡¡ There is no significant difference between academic performance of students taught using Creative problem-solving and taught using conventional lecture method,nature of data collected was interval,the groups was independent related. The statistical tool used for analyses was t-test.

¡V There is no significant difference between academic performance of students taught using Analytic, Creative problem-solving and taught using conventional lecture method, the nature of data collected was interval, the groups was independent related, mean, and standard deviation for descriptive and the statistical tool used for analyses was t-test.

V There is no significant difference between the responses of students taught using Analytic, Creative problem-solving and taught using conventional lecture method. The groups was independent related, mean, and standard deviation for descriptive and the statistical tool used to analyses was Kruskal-Wallis test. With 0.05 level of significant.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

The data presentation, analysis of the collected data and discussion are presented in this chapter. The data collected were analyzed using the statistical package for social science (SPSS) t-test and Kruskal-Wallis were used in the data analysis, and the level of significance adopted for rejecting or retaining the stated hypothesis was 0.05. Hence, this chapter comprises:

- Data Presentation;
- Data Analysis;
- Summary of Major Finding;
- Discussion

4.2 Data Presentation;

Three types of data were collected from the participants of this study;

1. Pre-test, post-test score of students Analytic Problem Solving Performance Test (APT).
2. Pre-test, post-test score of students Creative Problem Solving Performance Test (CPT).
3. Pre-test of Students Problem-Solving Interest Questionnaire (SPIQ).

The performance score from the pre-test, post-test were compiled and recorded for the experimental 1, experimental 2 and control group. Each research question was linked to a

corresponding research hypothesis and they were taken together in the presentation of result. The pre-test data were obtained by the administration of APT, CPT and SPIQ before the commencement of the study. The administration of the APT, CPT AND SPIQ took place immediately after the treatment. Post-test data were generated by the re-administration of the APT to both experiments and control group, for two weeks after pre-test.

Descriptive statistic of students taught with Analytic and Creative Problem-Solving with respect to academic performance in mathematics was henceforth conducted and summarized using the table below:

Table 4.2.1 Summary of Analytic and Creative Problem-Solving.

Group	N	Mean	S.D	SD Error	Mean Diff
Experimental Group 1	43	13.67	2.35	0.36	0.33
Experimental Group 2	38	14.00	2.78	0.45	

Table 4.2.1. Summarized the results of the differences between the Analytic and Creative Problem-Solving on the academic performance of students in mathematics. From the above result, it was indicated that, the mean difference between both Analytic and Creative is 0.33. The mean score of Analytic was 13.67 while that of Creative was 14.00. This indicated that there is mean difference between both approaches.

Descriptive statistic on academic performance of students taught using Analytic Problem-Solving and those taught using lecture methods.

Table 4.2.2 Summary of Analytic Problem-Solving and Control Group

Group	N	Mean	S.D	SD Error	Mean Diff
Experimental Group 1	43	13.67	2.35	0.36	2.78
Control Group	49	10.90	5.10	0.71	

Table 4.2.2, indicated that Analytic Problem-Solving (Experimental Group 1) mean score is 13.67, while that of lecture method (Control Group) mean score is 10.90 and their difference were 2.78. This showed that Analytic Problem-Solving was more effective than lecture method.

Descriptive statistic on academic performance of students taught using Creative Problem Solving and those taught using lecture method.

Table 4.2.3 Summary of Creative Problem-Solving and Control Group.

Group	N	Mean	S.D	SD Error	Mean Diff
Experimental Group 2	38	14.00	2.78	0.45	3.10
Control Group	49	10.90	5.10	0.73	

Table 4.2.3 indicated that the performance of students taught mathematics, using Creative Problem-Solving (Experimental Group 2) was more effective than those taught using lecture method (Control Group).

Descriptive statistic on academic performance of male and female students taught using Analytic and Creative Problem-Solving.

Table 4.2.4a Summary of gender performance using Analytic Problem-Solving

Group	Gender	N	Mean	S.D	SD Error	Mean Diff
EG 1	Male 1	25	14.08	2.33	0.47	0.97
EG 1	Female	18	13.11	2.32	0.55	

Table 4.2.4b Summary of gender performance using Creative Problem-Solving

Group	Gender	N	Mean	S.D	SD Error	Mean Diff
EG 2	Male 2	26	14.23	2.60	0.55	0.73
EG 2	Female	12	13.50	3.21	0.93	

Table 4.2.4a and 4.2.4b showed result of male and female student performance in both Analytic and Creative Problem-Solving, it was indicated that the male performance of both Analytic and Creative Problem-Solving, perform better than females students.

Descriptive statistic on student's responses on interest, before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using lecture method.

Table 4.2.5 Summary of students response on interest taught using Analytic, Creative and lecture method.

Group	N	Mean rank	SD
Experimental Group 1	43	80.78	4.13
Experimental Group 2	38	61.09	3.02
Control Group	49	53.89	4.55

Table 4.2.5 showed result of student's responses on interest; before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using lecture method. From the table, Experimental Group 1 have mean rank of (80.78), while Experimental Group 2 have mean rank of (61.09) and Control Group has mean rank score of(53.89). This showed there was a change between the two approaches and control group.

4.3 Data Analysis

Testing of Null Hypothesis

In Chapter one, five hypotheses were formulated with the view to answering the research questions raised. In this section attempts were made to test the hypotheses at 0.05 level of significance.

Ho_1 There is no significant difference between the mean score of students taught using Analytic and Creative Problem-Solving on academic performance of students in learning mathematics.

To test the hypothesis, the post-test performance score of Analytic Problem-Solving (Experimental Group 1) and Creative Problem-Solving (Experimental Group 2) were subjected to the use of independent sample t-test, with the level of significant at $\alpha = 0.05$

Table 4.3.1 Summary of t-test Analytic and Creative Problem-Solving

Group	N	Mean	SD	DF	t	p	Remark
Experimental Group 1	43	13.67	2.35	79	0.571	0.569	Not sign
Experimental Group 2	38	14.00	2.7				

Not Significant p>0.05 level

Table 4.3.1 indicated that the t-test observed was t = 0.571 and p-value observed was p = 0.569. Therefore since the p-value is greater than level of significant 0.05,hence the H_0 is rejected thus, there was no significant difference between the students taught using Analytic and Creative Problem-Solving on academic performance in learning mathematics. We conclude that there was no significant difference between students taught using Analytic and Creative Problem-Solving on academic performance in learning mathematics.

Ho_2 There is no significant difference between performance of students taught mathematics using Analytic Problem-Solving and those students taught using with lecture method..

This hypothesis was tested the performance of students taught mathematics using Analytic Problem-Solving and those taught using lecture method. Shown below

Table 4.3.2 Summary of Independent Sample t-test in Analysis (Analytic)

Group	N	Mean	SD	DF	t	p	Remark
Experimental Group 1	43	13.67	2.35	90	3.274	0.002	Significant
Control Group	49	10.90	5.10				

Significant at p< 0.05 level.

Table 4.3.2. indicated that the result t-value observed was t = 3.274, while the p-value (p = 0.002) observed which was less than level of significant than 0.05,hence the H_0 is rejected thus, there was no significant difference between performance of students taught mathematics using Analytic Problem-Solving and those students taught using with lecture method. This implies that, there was significant difference between the performance of students taught mathematics using Analytic Problem-Solving and those students taught using with lecture method.

Ho_3 There is no significant difference between the performance of students taught mathematics using Creative Problem-Solving and those students taught using with lecture method.

This hypothesis was tested the performance of students taught mathematics using Creative Problem-Solving and those taught using lecture method. Shown below

Table 4.3.3 Summary of Independent Sample t-test (Creative)

Group	N	Mean	SD	DF	t	p	Remark
Experimental Group 2	38	14.00	2.7	85	3.375	0.001	Significant
Control Group	49	10.90	5.10				

Significant $p< 0.05$ level

Table 4.3.3. indicated that the result of t-value observed was t = 3.375, while the p-value observed was 0.001, which is less than level of significant 0.05, hence the H_0 is rejected thus, there was significant difference between performance of students taught mathematics using Creative Problem-Solving and those students taught using with lecture method.

Ho_4 There is no significant difference between the performance of male and female students taught using Analytic and Creative Problem-Solving.

To test the hypothesis, the scores of students were subjected to t-test at 0.05 level of significance. The detailed analysis is presented below.

Table 4.3.4a. Independent Samples t-Test by Gender (Analytic)

Group	Gender	N	Mean	S.D	DF	t	p
EG 1	Male	25	14.08	2.33	41	0.12	0.185
EG 1	female	18	13.11	2.32			

Not Significant p> 0.05 level

Table 4.3.4, indicated that the result of mean performance of male was better than, that of female. This indicated that the male perform well than female.

Table 4.3.4bIndependent Samples t-Test by Gender (Creative)

Group	Gender	N	Mean	S.D	DF	t	p	Remark
EG 2	Male	26	14.23	2.597	36	1.086	0.459	Not Significant
EG 2	Female	12	13.12	3.21				

Not Significant p>0.05 level.

Table4.3.4b indicated that the result of mean performance of Male was better than the mean performance of female. And also t-value observed of both male and female was t = 0.012 and 1.086, while the p=0.185 and 0.459. Both results were greater than level of significant 0.05, hence the H_0 is fail rejected thus, This implies that, there was no significant difference between the performance of students taught mathematics using Analytic and Creative Problem-Solving.

Ho_5 There is no significant difference between student's responses on interest; before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method.

To test the hypothesis, the scores of students were subjected to Kruskal-Wallis test at 0.05 level of significance. The detailed analysis is presented below

Table 4.3.5 Interest response Analyzed using Krukal-Wallis test.

Group	N	Mean rank	SD	χ^2	p	Remark
Experimental Group 1	43	80.78	4.13	11.38	0.003	Significant
Experimental Group 2	38	61.09	3.02			
Control Group	49	53.89	4.55			

Significant at $p < 0.05$ level

Table4.3.5, indicated that the result chi- square observed was $\chi^2 = 11.38$ and p- value observed was p = 0.003. Therefore since the p - value was less than level of significant 0.05 level of significant, hence the H_0 is rejected thus, there was significant difference between student's responses on interest; before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method.

4.4 Summary of Major Findings

The following findings were made from the hypothesis testing of the Effect of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari, Kaduna State, Nigeria. The finding was made after the treatment and analysis of the post test result are as follows:

1. There was no significant difference on the performance between Analytic and Creative Problem-Solving on students' academic performance in mathematics.

2. There was significant difference on the performance of students taught mathematics using Analytic Problem-Solving and those using taught using lecture method.

3. There was significant difference on the performance of students taught mathematics using Creative Problem-Solving and those taught using lecture method.

4. There was no significant difference on the performance between male and female students taught using Analytic and Creative Problem-Solving.

5. There was significant difference between student's responses on interest, before and after being taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method.

4.5 Discussions

The major purpose of this research is to investigate the Effect of Analytic and Creative Problem-Solving on interest and performance in mathematics among senior secondary school students, Sabon-Gari, Kaduna State, Nigeria. In order to achieve the objectives of this study, five (5) null hypotheses were formulated and tested; the findings obtained from the hypotheses tested are discussed as follows:

The result on Table 4.3.1. Indicated that there was no significant difference between Analytic and Creative Problem-Solving on academic performance of students taught mathematics using the both are in agreement with the finding of Rabson, (2016). That there was no significant difference between Analytic and Creative Problem-Solving on academic performance of students taught using both approaches in mathematics. In their study, they revealed that students taught using the Analytic and Creative Problem-Solving, did not differ significantly in their both performances.

The result on Table 4.3.2. Indicated that there was a difference between the mean score of Experimental Group 1 (Analytic) and Control Group (lecture method). There was a significant difference between the performance of students taught mathematics using analytic problem-solving and those taught using lecture method. The Experimental Group 1 (Analytic) had the higher mean score of 13.67 than the control group (lecture method), compared with those taught using lecture method with the mean score of 10.90. Those taught using Analytic Problem-Solving performed better than those taught using lecture method. This finding corroborated Whimbey, & Lochhead, (1991). Who stated that through adoption of effective Analytic Problem-Solving performance in Mathematics could be highly improved.

The result on Table 4.3.3. Indicated that there was no significant difference between performance of students taught mathematics using Creative Problem-Solving and those taught using lecture method. Experimental Group 2 (Creative) had the higher mean score of 14.00 than the control group (lecture method), compared with those taught using conventional lecture method with the mean score of 10.90. Thus, those taught using creative problem-solving performed better than those taught using lecture method. This finding was in line with Whimbey, & Lochhead, (1991).This finding is supported by Mwelese and Wanjala (2014) who stated that through adoption of effective analytic problem-solving performance in Mathematics could be highly improved.

However, in comparison of mean scores of students exposed to Analytic problem-solving and those taught using conventional lecture method showed no significant difference. Thus, the null hypothesis is retained. Similarly, the group exposed to analytic problem-solving show significant difference with their counterpart taught with lecture method only. This finding is supported by Mwelese and Wanjala (2014) who stated that through adoption of effective instructional approach performance in Mathematics could be highly improved.

However, in comparison of mean scores of students exposed to creative problem-solving and those taught using analytic problem-solving showed no significant difference. Thus, the null hypothesis is retained. This finding is in agreement with works of Case et al, 2003; Rule and Hillgan 2006, Kurumeh and Achor (2008) which maintained that hands on and minds on activities have positive effect on improving students' academic performance. Also the finding is consistent with that of Etukudo, 2000; Folorunso and Nwosu, 2000; Usman (2008). The non-significant. The result on Table 4.3.4. Indicated that there was no significant difference between the academic performance score of male and female students taught using Analytic and Creative Problem-Solving. In addition male and female students exposed using Analytic and Creative Problem-Solving did not differ significantly. It was generalized that. Analytic and Creative Problem-Solving was found to be gender friendly. This finding agrees with Le Storti, (2000) who said that, there was no significant difference between the performance of male and female students in Senior Secondary School Certificate Examination (SSCE) Mathematics, which is also in accordance with the finding of Obeka, (2008) which showed that, the use of innovative approaches in environmental education concepts of Geography proved to be effective in enhancing the performance of male and female students likewise gender friendly. Difference found between EXP 1 AND EXP 2 groups implies that analytic problem-solving is as effective as creative problem-solving in teaching mathematics. This is supported by Tsoho (2011); Mohd (2012); Khadala (2014) who found that student centered strategies is effective in students‟ performance in geometry. The reason for the difference in the achievement of the experimental groups and the control group is not far fetch from the fact that students were more likely to interact in an active way with the analytic problem-solving and creative problem-solving. Takawira and Matthias (2010) maintained that lecture method of teaching alone cannot fully develop students‟ ability to grasp Basic Science concepts. Also Mwelese and Nwajala (2014) maintained that the lecture method does not enhance students‟

participation, team work and peer interactions and so, the performance of students taught through the lecture method would certainly be discouraging. The other hypothesis is centered on gender. In this regards, the results in Table 4.6 and 4.7 shows that there is no significant difference between the males and females in their performance when exposed to problem solving. Also, no significant difference among the male and female when taught using the analytic problem-solving. The use of the creative problem-solving does not show any significance between male and female in either of the groups. This implies that the analytic problem-solving is as effective as the creative problem-solving in the performances of both sexes. This is supported by the findings of Brown and Abell (2007); Clark (2009); Akinyemi Foloshade (2010); who investigated the use of analytic problem-solving and creative problem-solving and maintained that each of this approach is capable of producing same results.

Different teaching approach draw attention to different learning outcomes Samuelson (2008). According to Samuelson (2008) students who work in analytic problem-solving classes and

Creative problem-solving classes were exposed to a higher level of reasoning and they accepted this reasoning as valid.

Contrarily, in the control group were the lecture method is employed; students generally interacted with the teacher which lead to a lower performance. The results of hypothesis on interest shown in Table 4.3.5. Indicated that there was significant difference between students's responses on interest, before and after taught mathematics using Analytic and Creative Problem-Solving and those taught using conventional lecture method. It was in agreement with the findings Tella (2007) on interest and concluded that active teaching improved interest of the students. The approach created high level of student's participation and increased their interest level. This is line with Tella (2007); Obeka (2009) and Haruna

(2015) their reports on interest related significant positive changes after the used of various active teaching approach. This also in accordance with finding of Bell (2015) signified that, there was a significant difference in the interest of students due to exposure to treatment The opportunity for active participation by the leaner provided for by the analytic problem-solving and creative problem-solving seems to arouse interest and consequently resulted into positive interest towards mathematics. The importance of a positive interest towards a subject leading to high academic performance has been emphasized by experts such as: Fraenkel and Wallen (2000); Bergeson et al (2000); Bolaji (2005); Aiyede (2007); Kadala (2014) have argued that a positive interest correlates positively with students‟ performance. Credible numbers of research outcomes have shown that the type and quality of instructional approach are very important variables affecting students‟ interested towards Mathematics (Pickens, 2005; Rasha et al, 2007, Yara 2009, Eniageju, 2010, Mohammed, 2012; Kadala 2014). In addition, the result agrees with findings of Olatoye (2001); Osborne (2009), Auwal (2014) who in assessing the interest of some science students towards science and impact of learning instructions approaches in Mathematics found that students‟ mean interested towards Science and Mathematics was significant while gender and class level of students did not significantly influence students‟ interested towards science. This discussion implies that analytic problem-solving and creative problem-solving showed significant change in students‟ interest and so the creative problem-solving and creative problem-solving instructional approaches could therefore be very essential in the teaching and learning of mathematics at the senior Secondary School level most specifically in Kaduna State Schools.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study examined the Effects of Analytic and Creative Problem-Solving on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari, Kaduna State, Nigeria. The study was restricted to Senior Secondary Schools in Sabon-Gari, Educational Zonal of Kaduna State. Three schools were used (these are Government Secondary School Bomo Zaria, Government Secondary School Sakadadi and Government Commercial College Zaria). This is because they were state owned Secondary Schools and regulated by the state ministry of Education. This chapter would be discussed in the following sub-headings.

5.2 Summary

5.3 Conclusions

5.4 Recommendations

5.5 Contributions to Knowledge

5.2 Summary

This study investigated capacity of Effect of Analytic and Creative Problem-Solving approaches on Interest and Performance in Mathematics among Senior Secondary School Students, Sabon-Gari, Kaduna State Nigeria. The study was restricted to Senior Secondary Schools in Sabon-Gari Educational Zonal of Kaduna State. One of the problems that prompted the researcher to conduct this study was explained, scope and significance of the

study were paraphrased accordingly. Five objectives with their corresponding research questions and null hypothesis were formulated and tested for this study.

In related literature were reviewed which provided the basic of the existing information about the problem of the study. The following sub-headings were discussed; Theoretical Framework on Analytic Problem Solving, Analytic Problem Solving Thinking, Analytic Problem Solving, Reasoning and Thinking in a Classroom Environment, Analytic Problem Solving Progress Monitoring, Theoretical Framework on Creative Problem Solving, The Concept of Creativity in Education, The Creative problem solving, General Intellectual Abilities, General Creativity and Mathematical Creative Problem Solving Ability, Implication of the Literature Reviewed to the Study.

Quasi-experimental design was used and study involved the use of two experimental and control group with emphasis on pre-test and post-test. The population of the study covered all the twelve (12) public senior secondary schools (SS2) those offering mathematics with the total number enrollments of two thousand one hundred and forty two students (2142) in senior secondary schools (SS2). One thousand and sixty six (1066) were male students and one thousand and seventy six (1076) were female students. As stated above in 3.3 population. Three schools were selected using stratified random sampling technique. Three validated instruments were adopted by the researcher namely; APT, CPT and SPIQ, the Analytic and Creative Problem-Solving Performance test and result analyzed using PPMC calculated was 0.95, while student problem-solving approach interest questionnaire split half method was used with reliability 0.86 using Cronbach Alpha.

The research questions raised were answered using descriptive statistics whereby the null hypothesis were tested using inferential statistics. The explained of Summary, finding, Conclusions, Recommendations and Contribution to Knowledge of the Study.

5.3 Conclusions

The findings of this study led to the following conclusions:

1. Analytic and Creative Problem-Solving that teachers use in teaching four (4) topics in mathematics have significant effects on student performance.

2. The use of Analytic and Creative Problem-Solving guided can facilitate learning of mathematics in the senior secondary schools.

3. Analytic and Creative Problem-Solving performance test according to gender reveals that both sexes in the experiment I, II groups show no significant effect when exposed to treatment.

4. The finding on students‟ interest before and after exposure to Analytic and Creative Problem-Solving showed influence on their interest. The students enjoyed teaching and learning of mathematics using Analytic and Creative Problem-Solving, since these allowed them to have interaction, discussion before coming to an acceptable possible solution of a given problem. These two approaches kept every learner very active and involved at every stage of finding solutions to problems. Thus interest of students is favorable and this in turn improved their mathematics performance. Therefore, either the Analytic or Creative Problem-Solving could be used by Mathematics teachers.

5.4 Recommendations

The findings of these study have several implications for the teaching and learning of Mathematics in Senior Secondary School levels. Based on these findings, the following recommendations are stated:

1. The teaching of analytic and creative problem-solving senior secondary school should be conducted in a manner that students will effectively understand and learn the approach taught. It should respect the views and ideas of the students since students‟ participation plays greater role in learners‟ performance.

2. The fact that higher mean was recorded in students‟ performance through the use of Analytic and Creative problem-solving, calls for teachers to acquaint themselves with the characteristics of this teaching method with a view to enhancing students' performance and outcomes in learning. This could be done through seminars, conferences and workshops to be organized by State government and professional bodies.

3. Teachers, colleges of Education and Universities should in-corporate Analytic and Creative Problem-Solving into their teaching curriculum so as to enhance teacher's trainers on how to teach effectively. This will ensure the development of its knowledge in teachers on training.

4. From time to time, the State government and the Local Education Authority should liaise and organize workshops for Mathematics teachers to educate them on the need for the use of Analytic and Creative Problem-Solving. This is to complement the efforts of the Millennium Development Goals (MDGs) for retraining Mathematics teachers.

5. Professional Association and Research Councils such as Mathematical Association of Nigeria (MAN), Science Teachers Association (STAN) and the Nigerian Educational and Research Development Council (NERDC) should incorporate use of Analytic and Creative Problem-Solving in their workshops so as to train their members to use Analytic and Creative Problem-Solving to make teaching effectively.

5.5 Contributions to Knowledge

The study has contributed to knowledge as follows

1. The study has brought used of analytic and creative Problem Solving instructional teaching Modules; which were used in teaching four topics in mathematics. This is capable of contributing in no small measure to knowledge in the area of research. Consequently students and researchers will find this work useful for further researches.

2. In various studies, interest changes were left out and was used in this study and found that positive change was attained using Analytic and Creative Problem-Solving.

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Appendix A

Department of Science Education,

Ahmadu Bello University, Zaria.

6th February, 2018.

Dear sir/madam.

REQUEST FOR VALIDATION OF INSTRUMENTS

I Rabiu Mohammed Sani, a Post graduate Student, Department Of Science Education (Mathematics Section) with registration number P15EDSC8028. I hereby write to request for validation of instruments. I am carrying out a research study, Effect of Analytic and Creative Problem-Solving on Interest and Performance of Mathematics among Senior Secondary School Students in Sabon-Gari, Kaduna State, Nigeria.

The request will be critically examine the instruments, clarity. Language appropriateness and adequately of the term in measuring what it supposed to measure. I wish my request will be granted consideration.

Yours faithfully.

Rabiu Mohammed Sani

P15EDSC8028

Appendix B

STUDENT PROBLEM-SOLVING INTEREST QUESTIONNAIRE

Section A: Bio-data

Name of School _____

Student Name: _____

Sex: Male [ ] Female [ ].

Dear Respondent,

I wish to request for your help to the necessary data on a research title "Effects of Analytic and Creative Problem-Solving on Interest and Performance in mathematics among senior secondary school students in Sabon-Gari Kaduna State, Nigeria.

This research is an academic exercise therefore, your honest response will help in improving the teaching and learning of mathematics using analytic and creative problem-solving approaches in your school.

Yours faithfully.

Rabiu Mohammed SANI.

Instruction: please indicate to what extent you agree with the following statements by choosing the corresponding option as stated below;

Rating: SA = strongly agree (4) A = Agree (3) D = Disagree (2) SD=strongly Disagree (1)

Section: B

S/N	Statement	SA	A	D	SD
1	I like Analytic and Creative problem-solving				

2	The most important aspect of learning Analytic and Creative problem-solving in mathematics is to know the rules and to be able to follow them.				
3	My mind goes blank and I am unable to think clearly when working problems Without Using Analytic and Creative problem-solving.				
4	I learn things quickly when using Analytic and Creative problem-solving.				
5	If you cram and practice enough Analytic and Creative problem-solving, you will be good in solving mathematics problems.				
6	Those who get the right answer in mathematics have understood the used of Analytic and Creative problem-solving.				
7	Analytic and Creative problem-solving should be learned as a set of algorithms and rules that cover all possibilities				
8	Analytic and Creative problem-solving learning is for the gifted.				
9	Analytic and Creative problem-solving rules by rote are important in mathematics.				
10	Learning formal aspects of mathematics (e.g. the correct way to write out calculations) as early as possible important than using Analytic and Creative problem-solving.				
11	Learners should learn mathematics in groups				
12	A conventional approach (teacher-centered) is the best way to teach students to solve mathematics problems than using Analytic and Creative problem-solving.				
13	Students should ask questions during teaching Analytic and Creative problem-solving lessons.				
14	Analytic and Creative problem-solving lessons is not good for my life.				

15	Students should often be confronted with novel problems to solve then using Analytic and Creative problem-solving.				
16	Students should be given notes to copy when learning mathematics using Analytic and Creative problem-solving.				
17	The teacher should create conditions to stimulate learners‟ to learn mathematics using Analytic and Creative problem-solving lessons on their own.				
18	Cooperative work in groups is good for efficient learning of mathematics using Analytic and Creative problem-solving.				
19	Students should discover for themselves, the desired conceptual knowledge in the learning process during the learning of mathematics using Analytic and Creative problem-solving.				
20	Learning Analytic and Creative problem- solving approach, I can see a change in my mathematics class.				

Aiyede, (2007).

Appendix C

Analytic Problem-Solving Performance Test (APT)

Post-test study for analytic experimental groups

Section A: Bio-data

Student's name_____

Name of School_____

Class _____ Sex: Male [ ] Female [ ]

Section B:

Please read the instructions below before answer any question.

Write your name, class and school in the space provided on the answer sheet.

Read each question carefully before answer.

Do not select more than one the option.

(1) Solve the following by factorization $x^2 - 6x = -9$

(a) $(x-3)(x+3)^2$ (b) $(x+3)(x+3)$ (c) $(x+3)(x-3)$ (e) $(x-3)^2$

(2) Let U = N, the set of natural number. A ={1,2,3,4,5,6}, B = {2,4,6,8,…….}

C= {5, 7, 8}. Find A^C

(a) {5, 7, 8…..} (b) { 2,4.6,8……} (c){7,8,9,10……..} (e){7, 4, 9, 1……..}

(3) Solve the following simultaneous equation. 3n+3y =6 and 2n-3y =4.

(a) 2 and 1 (b) 2 and 0 (c) 1 and 2. (e) -2 and -1

(4) Define a set

(a) Collection of Well defined object. (b) List of some students. (c) List of students. (e) List of people.

(5) Identify which one is correct sign of empty set.

(a) { } (b) (0) (c) 0 (e) ( )

(6) Distinguish equal set.

(a) 10 = 5-5 (b) -10 = 10 (c) 13 (e) 10 = 5+5

(7) Solve the following by factorization (x - 2) (x -3) = 12.

(a) × =1 or x =3 (b) x =3 or x =6 (c) x = -1 or x = 6. (e) × = 3 or x = - 6

(8) Solve the following using substitution method. 3m + n = 7 and 2m + n = 4

(a) M = 4 or n =8 (b) m = 3 0r n = 2 (c) m = 6 0r n = - 4 (e) m = 6 0r n = 4

(9) If U = {d, e, l, n, o, p, r, s, u}. A= {d, e, n, p, s} B = {o, p, r, u} and C= {d, e, n,s}. find $(A^1 \cap B^1)UC$

(a) {d, e, n} (b) {e, e, u, n, s} (c) {d, e, I, n, s} (e) {o, p r}

(10) Simplify the Following $x - \frac{5}{2} + x + \frac{2}{3}$.

(a) 6x +12/8 (b) 5x +7/6 (c) 12x - 11/6 (e) - 6x +12/8

(11) Simplify $3^{n-1} \times 3^{1-n}$

(a) 5 (b) 6 (c) 1 (e) 5

(12) Rationalize the following $\frac{4}{7-\sqrt{3}}$.

(a) 2√4 (b) 1/√4 (c) - 14/23 + 2√3/23. (e) 14/23 + 2√3/23

(13) Solve the following quadratic equation using formula method. $x^2 + 3x - 10 = 0$

(a) x = 16 or x = 5 (b) x = 1/2(-3 + √29) or x = 1/2(3 - √29)

(c) X = 5 or x=3 (e) x = 2 or x = 5

(14) Factorize $3p^2 - 10p + 3$.

(a) $(3p - 4)^2$ (b) 3(p - 1)(p - 3) (c) (p -1)(p - 3) (e) (3p - 1)(p - 3)

(15) Simplify $4^y = 8$

(a) 3(b) -3/2 (c) 3/2 (e) 4/3

(16) Express the following in their simplest form. √72

(a) 7 (b) 6√2 (c) 5√2 (e) 8

(17) Given that U = {all English alphabets}. X = {a, e, I, o, u} Y = {a, b, c, d, e, f}. find (XUY)

(a) {a, s, o,} (b) {r, b, c, f, e, g, l, o, u} (c) {u, o, f,} (e) {a, b, c, d, e, f, l, o, u}

(18) Solve using substitution method 3p + 3q = 0 and q - 2p = 12

(a) p = - 4, q = 4 (b) p = 4, q = 3 (c) p = 7, q = 4 (e) p = 4, q = 15

solve the equation x - 10/6+ 2x+ 57/9 = 0

(a) x = 10 (b) x = 4 (c) 5 (e) x = 6

(20) solve using elimination method 3p + 4q = 16 and $2p - q = 1\frac{1}{2}$

(a) p = 2, q = $2\frac{1}{2}$ (b) p = - 2, q = $2\frac{1}{2}$ (c) p = 4, q = $3\frac{1}{2}$ (e) p = -2, q = $2\frac{1}{2}$

Appendix D

Answers to AnalyticProblem-Solving Performance Test (PSPT)

Marking Scheme

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

Appendix E

Analytic Approach Problem-Solving Model and Crisis Decision Making Manual

Step	Description
Step 1: Identify the Problem	Determine the situation or condition that will exist in the future and is considered undesirable by members of the organization. In order to identify the problem, you need to size up the situation to make sure that you have the full picture. Size-up involves analyzing the current situation to determine: • What is happening (and not happening). • Who is involved? • What the stakes are. This information will enable you to identify the problem more accurately.
Step 2: Explore or Generating Alternatives	This step includes generating alternatives and evaluating them. You can generate alternatives through brainstorming, surveys, discussion groups, or other means. Alternatives should be evaluated using a consistent process. In a crisis, exploring alternatives involves: • **Identifying contingencies.** Consider the future and think about all of the things that can get in the way of solving the problem you are facing. • **Determining objectives.** Develop objectives that clearly state what you need to do to be successful. • **Identifying needed resources.** Identify the people, information (data), and things needed to resolve the problem.
Step 3: Select an Alternative	After you have evaluated each alternative, select the alternative that comes closest to solving the problem with the most advantages and fewest disadvantages. There may be repercussions to any solution selected. Carefully consider how the solution will be implemented before selecting an alternative. In a crisis, selecting an alternative involves building a plan that states: • Who • Will do what (and with whom) • By when

	• Where • How Plans need to be communicated to all parties involved.
Step 4: Implement the Solution	Take action to implement the selected solution. Implementation involves the following: • Developing an action plan (what steps are needed). • Determining objectives or measurable targets. • Identifying needed resources. • Identifying details of the action plan (who will do what, by when, where, and how, as applicable). • Using the plan to put the solution in place.
Step 5: Evaluate the Situation	Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation, identify if: the situation has changed, more or fewer resources are required, or a different alternative solution is required. Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.

David A. Whetten, Kim S. Cameron (1999).

Appendix F

Analytic problem-solving Lesson plan (1)

Class: SS11

Topic: Quadratic equation the use of factorization.

Week1 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving, solve quadratic equations by factorization method Using Analytic Problem Solving.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to factor equation.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving, moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APS. Such as, solve the following using factorization method. In quadratic equation if the expressed can be as a product of two linear factors, then one of such factor must be zero in order to make the equation zero. Then the teacher issue a question to solve based on the teaching method like, solve the following using factorization method. $x^2 - 6x = -9$.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?
- What the stakes information will enable you to identify the problem more accurately. and solves an example such as Solution. $x^2 - 6x = -9$. As the teacher said above.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to find the product of coefficient of x the result will be as constant. $x^2 - 6x + 9 = 0$

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. $x^2 - 6x = -9$. $x^2 - 6x + 9 = 0$.

$x^2 - 3x - 3x + 9 = 0$, $x(x - 3) - (3x - 9) = 0$, $x(x - 3) - 3(x - 3) = 0$,

$(x - 3)(x - 3) = 0$, $x - 3 = 0$ twice or $x = 3$ $\therefore$ $x = 3$.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (2)

Class: SS11

Topic: Quadratic equation the use of completing the square method.

Week1 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve quadratic equations use of completing the square method Using Analytic Problem Solving.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to factor equation.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. Another method of solving a quadratic equation was of completing the square method.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?
- What the stakes information will enable you to identify the problem more accurately. and solves an example such as Solution. $x^2 - 6x = -9$. As the teacher said above.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to find to solve an example such as. $x^2 - 6x + 8 = 0$ by Make sure the coefficient of $x^2 = 1$, if is not one, divide it by it coefficient, take

the constant term to the right hand-side, divide the coefficient of x by 2, square the result add both side,

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. And solve it to smallest units. x^2 - 6x -9 = 0. the coefficient of X^2 = 1, then take the constant term to the right hand-side, divide the coefficient of x by 2 square the result add both side , $X^2 - 6x + \left(-\frac{6}{2}\right)^2 = 9 + \left(-\frac{6}{2}\right)^2$

The teacher solve as below $X^2 - 6x + \left(\frac{36}{4}\right) = 9 + \frac{36}{4}$, $X^2 - 6x + \left(\frac{6}{2}\right)^2 = 9 + 9$, hence we have

$(x-3)^2 = 0$. I.e. $(x-3)^2 = 0$

Take the square root of both side. $x - 3 = \pm\sqrt{0}$, x = 3 twice. The solutions or root of the equation are x = 3 twice.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (3)

Class: SS11

Topic: Quadratic equation the use of formula.

Week2 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving, solve quadratic equations use of formula, Using Analytic Problem Solving.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to factor equation using completing the square method. **Introduction:** The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving, moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. In these case this method stems from the completing square method. When a quadratic expression a X^2 + bx +c = 0 is not factorize, then we apply method of completing square or formula.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?
- What the stakes information will enable you to identify the problem more accurately, and solves an example such as Solution. $x^2 - 6x = -9$. As the teacher said above.
- **Step2 Explore or Generating Alternatives:** the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to find to solve an example such as. $x^2 -6x+9 = 0$

a =1 b = -6 and c = 9

x^2 - 6x +9 = 0 as the teacher said above.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Using the formula method of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. And solve it to smallest units.

x^2 -6x+9 = 0 a =1 b = -6 and c = 9 You then substitute the values of a, b and c into the formula to find x

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad x = \frac{-(-6) \pm \sqrt{(-3)^2 - 4 \times 1 \times 9}}{2(1)}$$

$$x = \frac{6 \pm \sqrt{36 + 36}}{2}, \qquad = \frac{6 \pm \sqrt{0}}{2}$$

$\therefore x = \frac{6}{2}$ Or $x = \frac{6}{2}$.

X = 3 twice.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (4)

Class: SS11

Topic: Simultaneous Equation using substitution method.

Week2 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving tosolve Simultaneous Equation using substitution method. Using Analytic Problem Solving.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve Equations..

.**Introduction:** The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. These are equations in which the power of any unknown variable does not exceed unity and they come pair of either two or three depending on the number of unknowns. The two method of solving the equations are. (¡). Substitution method (¡¡) elimination.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?
- What the stakes information will enable you to identify the problem more accurately, and solves an example such as Solution. 3n + y = 5 and 2n - 3y = 7.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to find to solve an example such as. 3n + y = 5 and 2n - 3y = 7

Step3: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative.Simultaneous Equation using substitution method of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. And solve it to smallest units. Solution.

3n + y = 5 and 2n - 3y = 7

3n + y = 5 ---------- (1)

2n - 3y = 7 ---------- (2)

From equation (1) y =5 - 3n, Substituting for y in equation (2)

$\therefore$ 2n -3(5 - 3n) = 7 2n -15 + 9n = 7,

11n = 22, and n = $\frac{22}{11} = 2$

Putting n = 2 in equation (1)

3(2) + y - 5, 6 + y = 5 Y = 5 - 6, Y = -1

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (5)

Class: SS11

Topic: Simultaneous Equation using elimination method.

Week3 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving tosolve Simultaneous Equation using elimination method. Using Analytic Problem Solving.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve Simultaneous Equation using substitution method.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. These are equations in which the power of any unknown variable does not exceed unity and they come pair of either two or three depending on the number of unknowns. The two method of solving the equations are. (¡). Substitution method (¡¡) elimination.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?
- What the stakes information will enable you to identify the problem more accurately, and solves an example such as Solution. 3d +2e = 1 and 2d + e = 5.

- **Step2 Explore or Generating Alternatives:** the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to find to solve an example such as. 3d +2e = 1 and 2d + e = 5.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative.Simultaneous Equation using substitution method of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. And solve it to smallest units. Solution.

3d +2e = 1 and 2d + e = 5.

$\therefore$ [3d +2e = 1] x 1

[2d + e = 5] x 2

$\Rightarrow$ 3d - 2e = 1---------- (3)

4d + 2e = 10 ---------- (4)

Add 3and 4 7d = 11,

$\therefore$ d = $\frac{11}{7}$ we substitute d in equation (1)

$3\left(\frac{11}{7}\right) - 2e = 1$ $\Rightarrow \frac{33}{7} - 2e = 1$

33 -14e = 7, - 14e = 7 -33

$e = \frac{26}{74} = \frac{13}{7}$ $e = \frac{13}{7}$.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (6)

Class: SS11

Topic: Sets.

Week3 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve Set Using Analytic Problem Solving. The student should be to. Define a set, Distinguish the difference types of sets, and Solve mathematical problems using the concept of sets

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. Such as, a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

The collection of all letters in the English alphabets,

The collection of all old number between 1 - 30,

The list of all students taking mathematics in the class, and

The list of all groups in the school.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define sets properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. The teacher will also notify the students that the set has notations such as

Generally sets are denoted by a capital letters, example

U = {A, B, C….Z}, and their elements by lower cases letters, examples, {a,b,c…z}. The teacher also clarify by explaining that, When an element of a set X, it is written as a ƐX, when the symbol "ε" mean belongs to or is an "element of ". And if a is not an element of X it is denoted by is $\notin$ X where symbol $\notin$ denoted "does not belong to" and if both a and b belong to X we write a,b ε X. representation of a sets. A set is always represented by pair of brace { } enclosing the elements. Example X = {a,e,o,I,u}. The teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (7)

Class: SS11

Topic: Sets.

Week4 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve Set Using Analytic Problem Solving. The student should be able to know Types of sets. Singleton set, Null or empty set, Finite and sets, Equal set, Subset, Power set, Product set, and Universal set

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving was moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. Such as, a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

*Singleton set. This is a set having one element. If a is an element of a singleton say X, is written as X = {a}. For Example {set of teachers in school}.

*Null or empty set: this is a set that has no element and it is generally denoted by ϕ or { } example the set of all human beings with five legs.

*Finite and infinite set: a set is said to be finite if it has n distinct element, where n is a positive integer otherwise it is infinite. If X is a finite set then the numbers of the elements in X is denoted by n(X) or IXI and is called the order or cardinality of X. Example, the set of all English alphabets is finite.

*Equal set: let X and Y be any two sets, then we say x = y if every element of x an element in y, and vice versa. Example X = {1,3,5,7,9} and Y = { 1,3,5,7,9}.

*Subset: let X and Y be any two sets. If every element of X is also a member of Y, then X is called a subsets of Y and is donated as $X \subseteq Y$. Example X = {a,e,i,o,u} and Y = {all English alphabet}. $\therefore$ X $\subseteq$ Y.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define sets properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place. The teacher will also notify the students that the set has notations such as

*Singleton set. This is a set having one element. If a is an element of a singleton say X, is written as X = {a}. For Example {set of teachers in school}.

*Null or empty set: this is a set that has no element and it is generally denoted by ϕ or { } example the set of all human beings with five legs.

*Finite and infinite set: a set is said to be finite if it has n distinct element, where n is a positive integer otherwise it is infinite. If X is a finite set then the numbers of the elements in X is denoted by n(X) or IXI and is called the order or cardinality of X. Example, the set of all English alphabets is finite.

*Equal set: let X and Y be any two sets, then we say x = y if every element of x an element in y, and vice versa. Example X = {1,3,5,7,9} and Y = { 1,3,5,7,9}.

*Subset: let X and Y be any two sets. If every element of X is also a member of Y, then X is called a subsets of Y and is donated as $X \subseteq Y$. Example X = {a,e,I,o,u} and Y = {all English alphabet}. $\therefore$ X $\subseteq$ Y. The teacher also Continue clarify by explaining that.

*Power set: the set of all subsets of a given set is called the power set of that set. If Xis a set, then the power set of X is denoted by P(x) and if the cardinality of X is n, then the cardinality of P(x) is 2^n. Example X = {x1, x2, x3}. P(x) = {(x1), (x2), (x3), (x1, x2), (x1, x3,), (x2, x3), (x1, x2, x3), ϕ }

*product set: if X and Y are any two sets, then the product of X and y which is denoted as $X \times Y = \{(x, y): x \varepsilon X \text{ and } y \varepsilon Y\}$.

*Universal set: the set which contains all possible elements under discussion is called the universal set. The universal set is denoted by a symbols: U or any letter but in upper case.

Example

U = {all students in the school}. Y = {English alphabet}.

The teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (8)

Class: SS11

Topic: Sets.

Week4 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve Set Using Analytic Problem Solving. The student should be able to solve mathematical problems using the concept of set

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APSS. Such as, a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

The collection of all letters in the English alphabets,

The collection of all old number between 1 - 30,

The list of all students taking mathematics in the class, and

The list of all groups in the school.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define sets properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place.The teacher will explain and give an example s of a set such as.

Operations with sets: union of a set

If X and Y are any two sets, then the union of X and Y is a set whose elements are that f X and Y put together, this is usually denoted as $X \bigcup Y$. In other words, the elements of union of X and Y is such that if a belongs to X $\bigcup$ Y, then a belongs to at least X or Y or both. In set building form, it is representing by X $\bigcup$ Y = {a: a ε X or a ε Y}. Example

Given that $\bigcup$ = {all English alphabet}. X = {a, e, I, o, u} and Y = {a, b, c, d, e, f}. Find X$\bigcup$Y and n(X$\bigcup$Y). Combined the elements of X and Y together, and count the number of elements in X and Y we have. X $\bigcup$ Y = {a, b, c, d, e, f, I, o, u} and n(X$\bigcup$Y) = 9

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (9)

Class: SS11

Topic: Sets.

Week5 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve Set Using Analytic Problem Solving. The student should be able to solve mathematical problems using the concept of set

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APS. Such as, a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

The collection of all letters in the English alphabets,

The collection of all old number between 1 - 30,

The list of all students taking mathematics in the class, and

The list of all groups in the school.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define sets properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative. Factor the equation of above,

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place.The teacher will explain and give an example s of a set such as. The teacher will explain and give an example s of a set such as.

Let $\bigcup$ = N, the set of neutral numbers.

A= {1, 2, 3, 4, 5, 6,}, B = {2, 4, 6, 8…}, C = {5, 7, 8}. Find A^c

A^c arethe numbers that are not in A. A^c = {7, 8, 9, 10, 11, 12……}

The teacher will solve again find. B^C and C^C

B^C = {1, 3, 5, 7, 9, 10……..}. And

C^C= {1, 2, 3, 4, 6, 9, 10…….}.

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (10)

Class: SS11

Topic: surd

Week5 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve surd Using Analytic Problem Solving. The student should be able to, explain what is surds, Carry out arithmetical operations on surd, Find positive square roots of surd, and Solve surd equation.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve surd problems.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APS. Such as, A Surd are irrational numbers of the form a $b\sqrt{c}$ where a,b are real and c is real whose root is not exact. Example include $\sqrt{2},\ \sqrt{3}, \sqrt{5}, 3\sqrt{5}, 4\sqrt{21}.$ Note that: there is no exact number whose cube is 5, nor is there an exact number which when raised to the fourth power given 21. Surd which contain only the square root are called Quadratic surds.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening).
- Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

Basic rules of surds. There are two basic rules in operating with surd as.

$\sqrt{ab} = \sqrt{a} \times \sqrt{b}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ where a and b are positive real numbers and $b \neq 0$

Note: where simplification involves multiplication with surd, algebraic rules of manipulations are employed. On the other hand, if division are involved with surds denominator, we rationalize the denominator.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define surds properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative.

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place.The teacher will explain and give an example s to solve the follows. Express the following in the simplest form

$$\sqrt{12} = \sqrt{4 \times 3} = \sqrt{4} \times \sqrt{3} = 2\sqrt{3}$$

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (11)

Class: SS11

Topic: surd

Week6 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve surd Using Analytic Problem Solving. The student should be able to solve addition, subtraction and multiplication of surd.

Instructional material: textbook and chalkboard. **Instructional techniques:** question and answering. **Entry behavior:** the students have learn on how to solve surd problems.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APS. Such as, A Surd are irrational numbers of the form a $b\sqrt{c}$ where a,b are real and c is real whose root is not exact. Example include $\sqrt{2},\ \sqrt{3}, \sqrt{5}, 3\sqrt{5}, 4\sqrt{21}.$ Note that: there is no exact number whose cube is 5, nor is there an exact number which when raised to the fourth power given 21. Surd which contain only the square root are called Quadratic surds.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem. (1) What is happening (and not happening). (2) Who is involved?

What the stakes information will enable you to identify the problem more accurately. The teacher will explain and give an example s of a set such as.

Basic rules of surds. There are two basic rules in operating with surd as.

$\sqrt{ab} = \sqrt{a} \times \sqrt{b}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ where a and b are positive real numbers and $b \neq 0$

Note: where simplification involves multiplication with surd, algebraic rules of manipulations are employed. On the other hand, if division are involved with surds denominator, we rationalize the denominator. **Step2 Explore or Generating Alternatives:** the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define surds properties. **Step3 Select an Alternative:** the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative.

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place.The teacher will explain and solves an example such as.

Simplify: $5\sqrt{2} + 3\sqrt{2} = (5 + 3)\sqrt{2} = 5\sqrt{2} + 3\sqrt{2} = 8\sqrt{2}$

The teacher will solve as follows. Simplify: $15\sqrt{3} - 2\sqrt{3} = (15\text{-}2)\sqrt{3} = 13\sqrt{3}$.

The teacher also solve multiplication of surd. Evaluate the follow. $(2\sqrt{3} - 3)(\sqrt{3} + 2)$

$= 2\sqrt{3} \times \sqrt{3} + 2 \times 2\sqrt{3} - 3 \times \sqrt{3} - 3 \times 2 \Rightarrow = 6 + 4\sqrt{3} - 3\sqrt{3} - 6 = 4\sqrt{3} - 3\sqrt{3} = \sqrt{3}$

The teacher will explain and give an example s to solve the follows. Express the following in the simplest form $\sqrt{12} = \sqrt{4 \times 3} = \sqrt{4} \times \sqrt{3} = 2\sqrt{3}$

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Lesson plan (12)

Class: SS11

Topic: surd

Week6 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Analytic Problem Solving to solve surd Using Analytic Problem Solving. the student should be able to solve division, conjugate and rationalization of denominator of surd

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve addition, subtraction and multiplication of surd problems.

Introduction: The teacher will form groups of five to eight students. He then introduces the lesson by reviewing the steps in Analytic Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with APS. Such as, The Surds a+ $\sqrt{b}$ and a - $\sqrt{b}$ are said to be conjugate of one another. Thus conjugate of

a - $\sqrt{b}$ is simply obtained by changing the sign between the terms.

A and $\sqrt{b}$ to be opposite sign. Hence the conjugate of $-2\sqrt{5}+4\sqrt{7}$ is $-2\sqrt{5}-4\sqrt{7}$ and vise vesa conjugate surds are very useful in rationalizing denominators of problems in rational forms which have surds in their denominators.

Instructional procedure: **Step1 Identify the Problem:** the teacher will identify the Problem

- What is happening (and not happening). •Who is involved?

What the stakes information will enable you to identify the problem more accurately. the teacher will explain and give an example s of a set such as.

Basic rules of surds. There are two basic rules in operating with surd as.

$\sqrt{ab} = \sqrt{a} \times \sqrt{b}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ where a and b are positive real numbers and $b \neq 0$

Note: where simplification involves multiplication with surd, algebraic rules of manipulations are employed. On the other hand, if division are involved with surds denominator, we rationalize the denominator.

Step2 Explore or Generating Alternatives: the teacher will explore or Generating Alternatives and The students are to learn how to generate as many ideas as possible to define surds properties.

Step3 Select an Alternative: the teacher will select an Alternative. Carefully consider how the solution will be implemented before selecting an alternative.

Step4 Implement the Solution: the teacher will implement the Solution together with the students. Using the plan to put the solution in place.The teacher will explain and solves an example such as. Find the product of the follow surd with conjugate $\sqrt{y} + 2x$

The conjugate of $\sqrt{y} + 2$ is $\sqrt{y} - 2 \Rightarrow \left(\sqrt{y} + 2x\right)\left(\sqrt{y} - 2x\right) = y - 4x^2$

$$= (5 + 3)\sqrt{2} \quad = \quad 5\sqrt{2} + 3\sqrt{2} \quad = 8\sqrt{2}$$

The teacher will solve as follows. Simplify: $\frac{1}{6+\sqrt{2}}$

$$\frac{1}{6+\sqrt{2}} = \frac{1}{6+\sqrt{2}} \times \frac{6-\sqrt{2}}{6-\sqrt{2}} = \frac{6-\sqrt{2}}{36-2} = \frac{6-\sqrt{2}}{34} = \frac{3}{17} - \frac{\sqrt{2}}{34}$$

The teacher also solve division of surd. Evaluate $\frac{2\sqrt{3}+1}{5-\sqrt{3}}$. It should be noted that the problem is a division problem. Thus we sought first for the conjugate of the denominator i.e. 5+ $\sqrt{3}$ .then processed by rationalization.

$$\frac{2\sqrt{3}+1}{5-\sqrt{3}} = \frac{2\sqrt{3}+1}{5-\sqrt{3}} \times \frac{5+\sqrt{3}}{5+\sqrt{3}} = \frac{\left(2\sqrt{3}+1\right)\left(5+\sqrt{3}\right)}{\left(5-\sqrt{3}\right)\left(5+\sqrt{3}\right)}$$

$$= \frac{10\sqrt{3}+6+5+\sqrt{3}}{3\sqrt{2}+1} = \frac{11\sqrt{3}+11}{22} = \frac{1\sqrt{3}}{2} + \frac{1}{2}$$

Step5 Evaluate the Situation. Evaluation involves monitoring progress and evaluating the decision that was made. During evaluation or Monitoring the success of a solution is an ongoing process that is critical to fine tuning a course of action.(Performance assessment): the teacher issue the student some questions to solve in the class.

Appendix G

Creative Problem-Solving Performance Test (CPT)

Post-test study for analytic experimental groups

Section A: Bio-data

Student's name_____

Name of School_____

Class _____ Sex: Male [ ] Female [ ]

Section B:

Please read the instructions below before answer any question.

Write your name, class and school in the space provided on the answer sheet.

Read each question carefully before answer.

Do not select more than one the option.

(2) Solve the following by factorization $x^2 - 6x = -9$

(b) $(x-3)(x+3)^2$ (b) $(x+3)(x+3)$ (c) $(x+3)(x-3)$ (e) $(x-3)^2$

(3) Let U = N, the set of natural number. A ={1,2,3,4,5,6}, B = {2,4,6,8,…….}

C= {5, 7, 8}. Find A^C

(b) {5, 7, 8…..} (b) { 2,4.6,8……} (c){7,8,9,10……...} (e){7, 4, 9, 1……..}

(4) Solve the following simultaneous equation. 3n+3y =6 and 2n-3y =4.

(a) 2 and 1 (b) 2 and 0 (c) 1 and 2. (e) -2 and -1

(4) Define a set

(b) Collection of Well defined object. (b) List of some students. (c) List of students. (e) List of people.

(5) Identify which one is correct sign of empty set.

(a) { } (b) (0) (c) 0 (e) ( )

(6) Distinguish equal set.

(a) 10 = 5-5 (b) -10 = 10 (c) 13 (e) 10 = 5+5

(7) Solve the following by factorization (x - 2) (x -3) = 12.

(a) × =1 or x =3 (b) x =3 or x =6 (c) x = -1 or x = 6. (e) × = 3 or x = - 6

(8) Solve the following using substitution method. 3m + n = 7 and 2m + n = 4

(a) M = 4 or n =8 (b) m = 3 0r n = 2 (c) m = 6 0r n = - 4 (e) m = 6 0r n = 4

(10) If U = {d, e, l, n, o, p, r, s, u}. A= {d, e, n, p, s} B = {o, p, r, u} and C= {d, e, n,s}. find $(A^1 \cap B^1)UC$

(b) {d, e, n} (b) {e, e, u, n, s} (c) {d, e, I, n, s} (e) {o, p r}

(10) Simplify the Following $x - \frac{5}{2} + x + \frac{2}{3}$.

(a) 6x +12/8 (b) 5x +7/6 (c) 12x - 11/6 (e) - 6x +12/8

(11) Simplify $3^{n-1} \times 3^{1-n}$

(a) 5 (b) 6 (c) 1 (e) 5

(13) Rationalize the following $\frac{4}{7-\sqrt{3}}$.

(b) 2√4 (b) 1/√4 (c) - 14/23 + 2√3/23. (e) 14/23 + 2√3/23

(14) Solve the following quadratic equation using formula method. $x^2 + 3x - 10 = 0$

(b) x = 16 or x = 5 (b) x = 1/2(-3 + √29) or x = 1/2(3 - √29)

(c) X = 5 or x=3 (e) x = 2 or x = 5

(15) Factorize $3p^2 - 10p + 3$.

(b) $(3p - 4)^2$ (b) 3(p - 1)(p - 3) (c) (p -1)(p - 3) (e) (3p - 1)(p - 3)

(16) Simplify $4^y = 8$

(a) 3(b) -3/2 (c) 3/2 (e) 4/3

(16) Express the following in their simplest form. √72

(a) 7 (b) 6√2 (c) 5√2 (e) 8

(18) Given that U = {all English alphabets}. X = {a, e, I, o, u} Y = {a, b, c, d, e, f}. find (XUY)

(b) {a, s, o,} (b) {r, b, c, f, e, g, l, o, u} (c) {u, o, f,} (e) {a, b, c, d, e, f, l, o, u}

(18) Solve using substitution method 3p + 3q = 0 and q - 2p = 12

(a) p = - 4, q = 4 (b) p = 4, q = 3 (c) p = 7, q = 4 (e) p = 4, q = 15

solve the equation x - 10/6+ 2x+ 57/9 = 0

(a) x = 10 (b) x = 4 (c) 5 (e) x = 6

(20) solve using elimination method 3p + 4q = 16 and $2p - q = 1\frac{1}{2}$

(a) p = 2, q = $2\frac{1}{2}$ (b) p = - 2, q = $2\frac{1}{2}$ (c) p = 4, q = $3\frac{1}{2}$ (e) p = -2, q = $2\frac{1}{2}$

Appendix H

Answers creative toProblem-Solving Performance Test (PSPT)

Marking Scheme

21. E
22. C
23. B
24. A
25. A
26. E
27. C
28. B
29. C
30. C
31. C
32. E
33. B
34. E
35. C
36. B
37. E
38. A
39. B
40. A

Appendix I

Creative Approach Problem-Solving Model and Crisis Decision Making Manual

Step	Description
Step1 clarification of the problem	The students will receive a copy of three projects with three different sets of criteria that will thoroughly be reviewed. They will then be given another sheet with solutions for the problem and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.
Step2 brainstorming	The groups will be given (one at a time) a list of broad topics and they will have to generate as many responses as possible. It will be done as a game. The winner is the group that has the most responses. There will be an emphasis on quantity and non-judgmental attitude.
Step3 evaluation/selection	Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.
Step4 Implementation	Here the group will decide upon how they will choose to do the project. Since this is not the actual project, one representative from each group will describe how the group chose to implement it. There will be emphasis on making each part of this unit as much like a game as possible. On the second day, the class will again be divided into groups.

VonOech, Roger (1990). A Whack on the Side of the Head. New York: Wagner Good examples of exercises in Creative Problem Solving.

Appendix J

Creative problem solving Lesson plan (1)

Class: SS11

Topic: Quadratic equation the use of factorization.

Week1 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, Students will be able to state the sequence of steps involved in Creative Problem Solving to solve quadratic equations by factorization method. Using Creative Problem Solving.

Instructional material: Rough paper,textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn how to factor equation using steps involved in Creative Problem Solving.

Introduction: The teacher will either allows the students to form their own groups of five to eight students or chooses the groups himself. He then introduces the lesson by reviewing the steps in Creative Problem Solving to moves into the actual problem. This lesson will serve as a review of the basic concepts and will allow the students actual practice with CPSS. Such as, solve the following using factorization method.

$X^2 - 6x = -9$. **Instructional procedure:**

Step1: CLARIFICATION OF THE PROBLEM "To solve this problem, you must use information you already know about the use of factorization method. You will need to do more than one step. It is also important to keep in mind that there is more than one way to solve this problem, but only one solution. Remember you are looking for x. There will be those of you who immediately see the answer. If you see

it, resist the urge to solve and go along with the four phases. Remember, you are learning a technique which can be used with more complex problems. The teacher should encourage the brighter students in each group to act as leaders, guiding the group through the four phases.

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve factorization method on Creative Problem Solving. "Now that everyone is clear on the factorization, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3: EVALUATION/SELECTION The group reviews each suggestion keeping in mind the criteria, and selects the best choice. “Now that each group has generated a list, the time has come for you to be more selective. Keeping the criteria in mind, review each suggestion and see which the best fit is."

IMPLEMENTATION. During this phase the groups are actually doing the math calculations. They use the information generated during the previous phase as well as any solution. “Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists.” At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPSS can be used.

Lesson plan (2)

Class: SS11

Topic: Quadratic equation the use of completing the square method.

Week1 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve quadratic equations by completing the square method. Students and to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to factorization equation and sequence of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Quadratic equation the use of completing the square method..

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve this problem $x^2 - 6x + 9=0$, you must use information you already know about Quadratic equation the use of completing the square method.. You will need to do more than one step. It is also important to keep in mind that there is more than one way to solve this problem, but only one solution. Remember you are looking for the number of x."

There will be those of you who immediately see the answer. If you see it, resist the urge to solve and go along with the four phases. Remember, you are learning a technique which can be used with more complex problems. The teacher should encourage the students, guiding the group through the four phases

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Quadratic equation the use of completing the square method. On Creative Problem Solving. "Now that everyone is clear on the Quadratic equation the use of completing the square method.., each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3: EVALUATION/SELECTION The group reviews each suggestion keeping in mind the criteria, and selects the best choice. "Now that each group has generated a list, the time has come for you to be more selective. Keeping the criteria in mind, review each suggestion and see which the best fit is."

Step4: IMPLEMENTATION During this phase the groups are actually doing the math calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (3)

Class: SS11

Topic: Quadratic equation the use of formula.

Week1 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Quadratic equation the use of formula. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Quadratic equation the use of completing the square method. Of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Quadratic equation the use of completing the square method..

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve this problem $x^2 - 6x + 9=0$, you must use information you already know about Quadratic equation the use of formula. You will need to do more than one step. It is also important to keep in mind that there is more than one way to solve this problem, but only one solution. Remember you are looking for the number of X."

There will be those of you who immediately see the answer. If you see it, resist the urge to solve and go along with the four phases. Remember, you are learning a technique which can be used with more complex problems.

The teacher should encourage the students, guiding the group through the four phases

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Quadratic equation the use of formula. On Creative Problem Solving. "Now that everyone is clear on the Quadratic equation the use of formula, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3: EVALUATION/SELECTION The group reviews each suggestion keeping in mind the criteria, and selects the best choice. "Now that each group has generated a list, the time has come for you to be more selective. Keeping the criteria in mind, review each suggestion and see which the best fit is."

Step4: IMPLEMENTATION During this phase the groups are actually doing the math calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (4)

Class: SS11

Topic: Simultaneous Equation using substitution method.

Week2 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Simultaneous Equation using substitution method. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Simultaneous Equation using substitution method. Of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Simultaneous Equation using substitution method.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve this problem $3n + y = 5$ and $2n - 3y = 7$. The students will receive three solutions copies with three different sets of criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problem and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Simultaneous Equation using substitution method. On Creative Problem Solving. "Now that everyone is clear on the Quadratic equation the use of formula, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that

sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the math calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (5)

Class: SS11

Topic: Simultaneous Equation using elimination method.

Week3 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Simultaneous Equation using elimination method. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Simultaneous Equation using elimination method. Of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Simultaneous Equation using elimination method.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve this problem 3d +2e = 1 and 2d + e = 5. The students will receive three solutions copies with three different sets of criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problem and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Simultaneous Equation using elimination method. On Creative Problem Solving. "Now that everyone is clear on the Simultaneous Equation using elimination method. Each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when

something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the math calculations. They use the information generated during the previous phase as well as any solution.

“Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists.” At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (6)

Class: SS11

Topic: Set.

Week3 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Set. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to set. Of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Set.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve Set problem, you must be identified all the properties of a Set. The students will receive different set of criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Set. On Creative Problem Solving. "Now that everyone is clear on the Set components, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (7)

Class: SS11

Topic: Sets.

Week4 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Set. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to set. Of steps involved in Creative Problem Solving.

Introduction: The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Set.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve Set problem, you must be familiar all the properties of a Set such as *Singleton set. This is a set having one element. If a is an element of a singleton say X, is written as X = {a}. For Example {set of teachers in school}.

*Null or empty set: this is a set that has no element and it is generally denoted by ϕ or { } example the set of all human beings with five legs.

*Finite and infinite set: a set is said to be finite if it has n distinct element, where n is a positive integer otherwise it is infinite. If X is a finite set then the numbers of the elements in X is denoted by n(X) or IXI and is called the order or cardinality of X. Example, the set of all English alphabets is finite.

*Equal set: let X and Y be any two set, then we say x = y if every element of x an element in y, and vice versa. Example X = {1,3,5,7,9} and Y = { 1,3,5,7,9}.

*Subset: let X and Y be any two sets. If every element of X is also a member of Y, then X is called a subset of Y and is donated as $X \subseteq Y$. Example X = {a, e, i, o, u} and Y = {all English alphabet}. $\therefore$ X $\subseteq$ Y.

Step2: the teacher act on plan by Continue clarify by explaining that.

*Power set: the set of all subset of a given set is called the power set of that set. If Xis a set, then the power set of X is denoted by P(x) and if the cardinality of X is n, then the cardinality of P(x) is 2^n.

Example X = {x1, x2, x3}. P(x) = {(x1), (x2), (x3), (x1, x2), (x1, x3,), (x2, x3), (x1, x2, x3), ϕ }

*product set: if X and Y are any two set, then the product of X and y which is denoted as $X \times Y = \{(x, y): x \varepsilon X \text{ and } y \varepsilon Y\}$.

*Universal set: the set which contains all possible elements under discussion is called the universal set. The universal set is denoted by a symbols: U or any letter but in upper case.

Example

U = {all students in the school}. Y = {English alphabet}.

.The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. The students are learning how to generate as many ideas as possible. The teacher must stress the non-critical attitude of the group and explain that often ideas that appear to have nothing to do with the criteria are useful in generating other solutions, even if they are not appropriate as the solution themselves. In order to illustrate the importance of brainstorming and how seemingly unrelated ideas can lead to a solution, the teacher can use this example, or something from his/her own experience. Each group develops a list of ideas about how to be familiar and solve problems of Sets on Creative Problem Solving. "Now that everyone is clear on the Set properties and solutions, each group

will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (8)

Class: SS11

Topic: Sets.

Week4 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Set. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to set. Of steps involved in Creative Problem Solving.

Introduction: The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Set.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve Set problem, you must be familiar all the properties of a Set such as Operations with set: union of a set. If X and Y are any two set, then the union of X and Y is a set whose elements are that f X and Y put together, this is usually denoted as $X \bigcup Y$. In other words, the elements of union of X and Y is such that if a belongs to X $\bigcup$ Y, then a belongs to at least X or Y or both. In set building form, it is representing by X $\bigcup$ Y = {a: a ε X or a ε Y}.The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. The students are learning how to generate as many ideas as possible. The teacher must stress the non-critical attitude of the group and explain that often ideas that appear to have nothing to do with the criteria are useful in generating other solutions, even if they are not appropriate as

the solution themselves. In order to illustrate the importance of brainstorming and how seemingly unrelated ideas can lead to a solution, the teacher can use this example, or something from his/her own experience.Each group develops a list of ideas about how to be familiar and solve problems of Set on Creative Problem Solving. "Now that everyone is clear on the Sets properties and solutions, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (9)

Class: SS11

Topic: Sets.

Week5 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Sets. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to set. Of steps involved in Creative Problem Solving.

Introduction: The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Set.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve Sets problem, you must be familiar all the properties of a Set such as Let $\cup$ = N, the set of natural numbers.

A= {1, 2, 3, 4, 5, 6,}, B = {2, 4, 6, 8…}, C = {5, 7, 8}. Find A^c

A^c arethe numbers that are not in A. A^c = {7, 8, 9, 10, 11, 12……}the teacher act on plan by solving problems such again. B^C and C^C

B^C = {1, 3, 5, 7, 9, 10……..}. And

C^C= {1, 2, 3, 4, 6, 9, 10…….}.The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. The students are learning how to generate as many ideas as possible. The teacher must stress the non-critical attitude of the group and explain that often ideas that appear to have nothing to do with the criteria are useful in generating other solutions, even if they are not appropriate as the solution themselves. In order to illustrate the importance of brainstorming and how seemingly unrelated ideas can lead to a solution, the teacher can use this example, or something from his/her own experience.Each group develops a list of ideas about how to be familiar and solve problems of Set on Creative Problem Solving. "Now that everyone is clear on the Sets properties and solutions, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (10)

Class: SS11

Topic: Surd

Week5 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Surd. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Surd. Of steps involved in Creative Problem Solving.

.**Introduction:** The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Surd.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To identify Basic rules of surds. There are two basic rules in operating with surd as. $\sqrt{ab} = \sqrt{a} \times \sqrt{b}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ where a and b are positive real numbers and $b \neq 0$

Note: where simplification involves multiplication with surd, algebraic rules of manipulations are employed. On the other hand, if division are involved with surds denominator, we rationalize the denominator. The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet for the solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. Each group develops a list of ideas about how to solve Surd. On Creative Problem Solving. "Now that everyone is clear on the Surd components/properties, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

"Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (11)

Class: SS11

Topic: Surd

Week6 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Surd. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Surd. of steps involved in Creative Problem Solving.

Introduction: The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Surd.

Instructional procedure: **Step1:** CLARIFICATION OF THE PROBLEM:" To solve Surd problem, you must be familiar all the properties and solve surd problems such as A Surd are irrational numbers of the form a $b\sqrt{c}$ where a, b are real and c is real whose root is not exact. Example include $\sqrt{2},\ \sqrt{3}, \sqrt{5}, 3\sqrt{5}, 4\sqrt{21}.$ Note that: there is no exact number whose cube is 5, nor is there an exact number which when raised to the fourth power given 21. Surd which contain only the square root are called Quadratic surds. The teacher will define and examine (example) the problem such as. Simplify:

$5\sqrt{2} + 3\sqrt{2} = (5 + 3)\sqrt{2} = 8\sqrt{2}$

The teacher act on plan by solving as follows. Simplify: $15\sqrt{3} - 2\sqrt{3} = (15\text{-}2)\sqrt{3} = 13\sqrt{3}$.

The teacher also solve multiplication of surd. Evaluate the follow. $(2\sqrt{3} - 3)(\sqrt{3} + 2)$

$= 2\sqrt{3} \times \sqrt{3} + 2 \times 2\sqrt{3} - 3 \times \sqrt{3} - 3 \times 2 \Rightarrow = 6 + 4\sqrt{3} - 3\sqrt{3} - 6 = 4\sqrt{3} - 3\sqrt{3} = \sqrt{3}$.

The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. The students are learning how to generate as many ideas as possible. The teacher must stress the non-critical attitude of the group and explain that often ideas that appear to have nothing to do with the criteria are useful in generating other solutions, even if they are not appropriate as the solution themselves. In order to illustrate the importance of brainstorming and how seemingly unrelated ideas can lead to a solution, the teacher can use this example, or something from his/her own experience.Each group develops a list of ideas about how to be familiar and solve problems of Surds on Creative Problem Solving. "Now that everyone is clear on the Sets properties and solutions, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice. **Step4:** IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution. "Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists." At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Lesson plan (12)

Class: SS11

Topic: surd

Week6 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve Surd. Students are to state the sequence of steps involved in Creative Problem Solving.

Instructional material: rough book,textbook and chalkboard.

Instructional techniques: question and answering about, the sequence of steps involved in Creative Problem Solving. **Entry behavior:** the students have learn on how to Surd. Of steps involved in Creative Problem Solving.

Introduction: The teacher introduces the lesson with the following: "You should now be more knowledgeable about the steps in Creative Problem Solving. Today we will combine this technique with something you should all be familiar with, Surd.

Instructional procedure:

Step1: CLARIFICATION OF THE PROBLEM:" To solve conjugate Surd problems, you must be familiar all the properties and solve surd problems such as product of the follow surd with conjugate

$\sqrt{y}+2x$ the conjugate of $\sqrt{y}+2$ is $\sqrt{y}-2 \Rightarrow \left(\sqrt{y}+2x\right)\left(\sqrt{y}-2x\right)=y-4\,\mathrm{x}^2$

= $(5+3)\sqrt{2}$ = $8\sqrt{2}$ the teacher act on plan by solving as follows.

Simplify: $\frac{1}{6+\sqrt{2}}$, $\frac{1}{6+\sqrt{2}}=\frac{1}{6+\sqrt{2}}\times\frac{6-\sqrt{2}}{6-\sqrt{2}}=\frac{6-\sqrt{2}}{36-2}=\frac{6-\sqrt{2}}{34}=\frac{3}{17}-\frac{\sqrt{2}}{34}$

The teacher also solve division of surd. Evaluate $\frac{2\sqrt{3}+1}{5-\sqrt{3}}$. It should be noted that the problem is a division problem. Thus we sought first for the conjugate of the denominator ie $5+\sqrt{3}$ .then processed by rationalization.

$$\frac{2\sqrt{3}+1}{5-\sqrt{3}} = \frac{2\sqrt{3}+1}{5-\sqrt{3}} \times \frac{5+\sqrt{3}}{5+\sqrt{3}} = \frac{\left(2\sqrt{3}+1\right)\left(5+\sqrt{3}\right)}{\left(5-\sqrt{3}\right)\left(5+\sqrt{3}\right)}$$

$$= \frac{10\sqrt{3}+6+5+\sqrt{3}}{3\sqrt{2}+1} = \frac{11\sqrt{3}+11}{22} = \frac{1\sqrt{3}}{2} + \frac{1}{2}$$

The students will receive copies of the above criteria that will thoroughly be observed. They will then be given another plane sheet with solutions of problems and each group will have to decide whether or not each solution met the criteria. This will give the students a better sense of the concept.

Step2: BRAINSTORMING. The students are learning how to generate as many ideas as possible. The teacher must stress the non-critical attitude of the group and explain that often ideas that appear to have nothing to do with the criteria are useful in generating other solutions, even if they are not appropriate as the solution themselves. In order to illustrate the importance of brainstorming and how seemingly unrelated ideas can lead to a solution, the teacher can use this example, or something from his/her own experience.Each group develops a list of ideas about how to be familiar and solve problems of Surds on Creative Problem Solving. "Now that everyone is clear on the Sets properties and solutions, each group will brainstorm possible solutions. Remember, during this phase you should not be criticizing each other's ideas. You never know when something that sounds crazy will connect to a solid idea. Have fun with it. If your group gets stuck, think wilder and crazier."

Step3 EVALUATION/SELECTION Using the lists that the group generated, they will be given a list of criteria and will eliminate and modify their choices until they are left with one choice.

Step4: IMPLEMENTATION During this phase the groups are actually doing the mathematics calculations. They use the information generated during the previous phase as well as any solution.

“Now it is time to actually solve the problem. Use the information you listed during the last two phases. Remember there is more than one step. If you are still having trouble solving the problem, return to your Brainstorming and Selection/Evaluation lists.” At the end of this activity the teacher allows a spokesperson from each group to share their experiences through the phases. As well, the class discusses how CPS can be used in other units and subjects.

Appendix K

Problem solving (Lecture Method) Lesson plan (1)

Class: SS11

Topic: Quadratic equation the use of factorization.

Week1 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve quadratic equations by factorization method. **Instructional material:** textbook and chalkboard. **Instructional techniques:** question and answering.

Entry behavior: the students have learn on how to factor equation.

Introduction: In quadratic equation if the expressed can be as a product of two linear factors, then one of such factor must be zero in order to make the equation zero. Then the teacher issue a question to solve based on the teaching method like, solve the following using factorization method. $x^2 - 6x = -9$. **Instructional procedure:**

Step1: the teacher will explain and solves an example such as Solution. $x^2 - 6x = -9$

$x^2 - 6x + 9 = 0$ as the teacher said above.

Step2: the teacher will find the product of coefficient of x the result will be as constant

$x^2 - 3x - 3x + 9 = 0$ **Step3:** the teacher factor the equation of above,

$x(x - 3) - (3x - 9) = 0$ $x(x - 3) - 3(x - 3) = 0$

$(x - 3)(x - 3) = 0$ $x - 3 = 0$ twice or $x = 3$ $\therefore$ $x = 3$.

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary. **Performance assessment (Evaluation):** the teacher issue the student some questions to solve in the class.

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (2)

Class: SS11

Topic: Quadratic equation the use of completing the square method.

Week1 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve quadratic equations by completing the square method.

Instructional material: textbook and chalkboard. **Instructional techniques:** question and answering. **Entry behavior:** the students have learn on how to factorization equation.

Introduction: Another method of solving a quadratic equation is the of completing the square method.

Instructional procedure: **Step1:** the teacher will explain and solves an example such as. Make sure the coefficient of $x^2 = 1$. Solution. $x^2 - 6x + 9=0$

Step2: take the constant term to the right hand-side, divide the coefficient of x by 2 square the result add both side, $x^2 - 6x+ \left(-\frac{6}{2}\right)^2 = - 9 + \left(-\frac{6}{2}\right)^2$ The teacher solve as below

$x^2 - 6x + \left(\frac{36}{4}\right) = -9 + \frac{36}{4}$, $x^2 - 6x + 9 = -9 + 9$, hence we have $\left(x-\frac{6}{2}\right)^2 = \pm \sqrt{0}$

i.e. $(x-3)^2 = \pm\sqrt{0}$

Step3: take the square root of both side. $x-3=0$, $x = 3$ or. the solutions or root of the equation are x =3 twice . **Performance assessment (Evaluation):** the teacher issue the student some questions to solve in the class.

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (3)

Class: SS11

Topic: Quadratic equation the use of formula.

Week2 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to solve quadratic equations by using formula method.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to factorization and completing the square method.

Introduction: this method stems from the completing square method. When a quadratic expression $ax^2 + bx + c = 0$ is not factorizable, then we apply method of completing square or formula.

Instructional procedure:

Step1: the teacher will explain and solves an example such as Solution. $x^2 - 6x = +9 = 0$

A =1 b = -6 and c = 9

$x^2 - 6x + 9 = 0$ as the teacher said above.

Step2: the teacher will make use of formula or apply formula.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad x = \frac{-(-6) \pm \sqrt{(-6)^2 - 4 \times 1 \times 9}}{2(1)}$$

$$x = \frac{6 \pm \sqrt{36 - 36}}{2}, \qquad = \frac{6 \pm \sqrt{0}}{2}$$

$$\therefore x = \frac{6}{2}, \text{ x = 3 twice.}$$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (4)

Class: SS11

Topic: Simultaneous Equation using substitution method.

Week2 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to able to solve Simultaneous Equation in two unknowns by method of elimination, substitution

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve equations.

Introduction: these are equations in which the power of any unknown variable does not exceed unity and they come pair of either two or three depending on the number of unknowns. The two method of solving the equations are. (¡). Substitution method (¡¡) elimination

Instructional procedure:

Step1: the teacher will explain and solves an example such as Solution. 3n + y = 5 and 2n - 3y = 7

3n + y = 5 ---------- (1)

2n - 3y = 7 ---------- (2)

From equation (1) y =5 - 3n, Substituting for y in equation (2)

∴ 2n -3(5 - 3n) = 7 2n -15 + 9n = 7,

11n = 22, and n = $\frac{22}{11} = 2$

Step2: Putting n = 2 in equation (1)

$3(2) + y - 5,$ $6 + y = 5$ $Y = 5 - 6,$ $Y = -1$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (5)

Class: SS11

Topic: Simultaneous Equation using elimination method.

Week3 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to solve Simultaneous Equation in two unknowns by method of elimination.

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to solve Simultaneous equations using substitution method.

Introduction: to solve Simultaneous linear Equation using elimination method.

¡ Number the equation

¡¡ rearrange equations so that like terms corresponding in the two equation

¡¡¡ identify the unknown that you want to eliminate. It is easier to choose unknown with smallest coefficient.

IV multiply the equation by the alternate coefficient of the chosen unknown so that the coefficient in the two equation become the same

V eliminate either by addition or subtraction

Instructional procedure:

Step1: the teacher will explain and solves an example such as Solution. 3d +2e = 1 and 2d + e = 5

$\therefore$ [3d +2e = 1] x 1

[2d + e = 5] x 2

$\Rightarrow$ 3d - 2e = 1---------- (3)

4d + 2e = 10 ---------- (4)

Add 3and 4 7d = 11,

$\therefore$ d = $\frac{11}{7}$

Step2: we substitute d in either equation

$3\left(\frac{11}{7}\right) - 2e = 1$ $\Rightarrow \frac{33}{7} - 2e = 1$

33 -14e = 7, - 14e = 7 -33

$$e = \frac{26}{74} = \frac{13}{7}$$

$$e = \frac{13}{7}.$$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (6)

Class: SS11

Topic: Sets.

Week3 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be to.

Define a set, Distinguish the difference types of set, and Solve mathematical problems using the concept of set

Instructional material: textbook, illustrations and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure:

Step1: the teacher will explain and give an example s of a set such as.

The collection of all letters in the English alphabets,

The collection of all old number between 1 - 30,

The list of all students taking mathematics in the class, and

The list of all groups in the school

Step2: the teacher will also notify the students that the set has notations such as

Generally sets are denoted by a capital letters, example

U = {A, B, C….Z}, and their elements by lower cases letters, examples, {a, b, c…z}.

Step3: the teacher also clarify by explaining that.

When a, is an element of a set X, it is written as a ƐX, when the symbol "ε" mean belongs to or is an "element of ", and if a is not an element of X it is denoted by is $\notin$ X where symbol $\notin$ denoted "does not belong to" and if both a and b belong to X we write a, b ε X. representation of a set. A set is always represented by pair of brace { } enclosing the elements. Example X = {a, e, o, i, u}

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (7)

Class: SS11

Topic: Sets.

Week4 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to know Types of set.

Singleton set, Null or empty set, Finite and sets, Equal set, Subset, Power set, Product set, and Universal set

Instructional material: textbook, illustrations and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure:

Step1: the teacher will explain and give an example s of a set such as.

* Singleton set. This is a set having one element. If a is an element of a singleton say X, is written as X = {a}. For Example {set of teachers in school}.

* Null or empty set: this is a set that has no element and it is generally denoted by ϕ or { } example the set of all human beings with five legs.

* Finite and infinite set: a set is said to be finite if it has n distinct element, where n is a positive integer otherwise it is infinite. If X is a finite set then the numbers of the elements in X is denoted by n(X) or IXI and is called the order or cardinality of X. Example, the set of all English alphabets is finite.

* Equal set: let X and Y be any two sets, then we say x = y if every element of x an element in y, and vice versa. Example X = {1,3,5,7,9} and Y = { 1,3,5,7,9}.

* Subset: let X and Y be any two sets. If every element of X is also a member of Y, then X is called a subset of Y and is donated as $X \subseteq Y$. Example X = {a, e, i, o, u} and Y = {all English alphabet}. $\therefore$ $X \subseteq Y$.

Step3: the teacher also Continue clarify by explaining that.

* Power set: the set of all subsets of a given set is called the power set of that set. If X is a set, then the power set of X is denoted by P(x) and if the cardinality of X is n, then the cardinality of P(x) is 2^n. Example X = {x1, x2, x3}. P(x) = {(x1), (x2), (x3), (x1, x2), (x1, x3,), (x2, x3), (x1, x2, x3), ϕ }

* product set: if X and Y are any two set, then the product of X and y which is denoted as $X \times Y = \{(x, y): x \varepsilon X \text{ and } y \varepsilon Y\}$.

* Universal set: the set which contains all possible elements under discussion is called the universal set. The universal set is denoted by a symbols: U or any letter but in upper case.

Example

U = {all students in the school}. Y = {English alphabet}.

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (8)

Class: SS11

Topic: Sets.

Week4 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to solve mathematical problems using the concept of sets

Instructional material: textbook, illustrations and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class. **Instructional procedure:**

Step1: the teacher will explain and give an example s of a set such as.

Operations with set: union of a set

If X and Y are any two set, then the union of X and Y is a set whose elements are that f X and Y put together, this is usually denoted as $X \bigcup Y$. In other words, the elements of union of X and Y is such that if a belongs to X $\bigcup$ Y, then a belongs to at least X or Y or both. In set building form, it is representing by X $\bigcup$ Y = {a: a ε X or a ε Y}. Example

Given that $\cup$ = {all English alphabet}. X = {a, e, I, o, u} and Y = {a, b, c, d, e, f}. Find X$\bigcup$Y and n(X$\bigcup$Y). Combined the elements of X and Y together, and count the number of elements in X and Y we have. X $\cup$ Y = {a, b, c, d, e, f, I, o, u} and n(X$\bigcup$Y) = 9

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class. **Conclusion:** the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (9)

Class: SS11

Topic: Sets.

Week5 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to solve mathematical problems using the concept of set

Instructional material: textbook, illustrations and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn on how to list class objects.

Introduction: a set is a well-defined collection, list or class of object. By well-defined we mean that whenever you take a look at an object it is possible to determine whether or not that object belongs to the collection, list or class.

Instructional procedure:

Step1: the teacher will explain and give an example s of a set such as.

Let $\cup$ = N, the set of neutral numbers.

A= {1, 2, 3, 4, 5, 6,}, B = {2, 4, 6, 8…}, C = {5, 7, 8}. Find A^c

A^c arethe numbers that are not in A. A^c = {7, 8, 9, 10, 11, 12……}

Step2: the teacher will solve again. B^C and C^C

B^C = {1, 3, 5, 7, 9, 10……..}. And

C^C= {1, 2, 3, 4, 6, 9, 10…….}.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (10)

Class: SS11

Topic: surd

Week5 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to.

Explain what is surd, Carry out arithmetical operations on surd, Find positive square roots of surd, and Solve surd equation

Instructional material: textbook and chalkboard. **Instructional techniques:** question and answering.

Entry behavior: the students have learn how to solve surd.

Introduction: A Surd are irrational numbers of the form a $b\sqrt{c}$ where a, b are real and c is real whose root is not exact. Example include $\sqrt{2},\ \sqrt{3}, \sqrt{5}, 3\sqrt{5}, 4\sqrt{21}.$

Note that: there is no exact number whose cube is 5, nor is there an exact number which when raised to the fourth power given 21. Surd which contain only the square root are called Quadratic surds.

Instructional procedure: Step1: the teacher will explain and solves an example such as

Basic rules of surds. There are two basic rules in operating with surd as.

$\sqrt{ab} = \sqrt{a} \times \sqrt{b}$ and $\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}}$ where a and b are positive real numbers and $b \neq 0$

Note: where simplification involves multiplication with surd, algebraic rules of manipulations are employed. On the other hand, if division are involved with surds denominator, we rationalize the denominator. **Step2**: the teacher will solve as follows. Express the following in the simplest form

$$\sqrt{12} = \sqrt{4\times 3} = \sqrt{4} \times \sqrt{3} = 2\sqrt{3}$$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (11)

Class: SS11

Topic: surd

Week6 Day: 1

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to solve addition, subtraction and multiplication of surd. **Instructional material:** textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn how to solve surd.

Introduction: A Surd are irrational numbers of the form $a\,b\sqrt{c}$ where a, b are real and c is real whose root is not exact. Example include $\sqrt{2},\ \sqrt{3}, \sqrt{5}, 3\sqrt{5}, 4\sqrt{21}.$

Note that: there is no exact number whose cube is 5, nor is there an exact number which when raised to the fourth power given 21. Surd which contain only the square root are called Quadratic surds.

Instructional procedure: Step1: the teacher will explain and solves an example such as.

Simplify: $5\sqrt{2} + 3\sqrt{2} = (5 + 3)\sqrt{2} = 8\sqrt{2}$

Step2: the teacher will solve as follows. Simplify: $15\sqrt{3} - 2\sqrt{3} = (15\text{-}2)\sqrt{3} = 13\sqrt{3}$.

Step3: the teacher also solve multiplication of surd. Evaluate the follow. $(2\sqrt{3} - 3)(\sqrt{3} + 2)$

$= 2\sqrt{3} \times \sqrt{3} + 2 \times 2\sqrt{3} - 3 \times \sqrt{3} - 3 \times 2 \Rightarrow = 6 + 4\sqrt{3} - 3\sqrt{3} - 6 = 4\sqrt{3} - 3\sqrt{3} = \sqrt{3}$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class. **Conclusion:** the teacher conclude his lesson by cheering the student while supervising their activities.

Lesson plan (12)

Class: SS11

Topic: surd

Week6 Day: 2

Duration: 90 minute

Instructional objectives: by the end of the lesson, the student should be able to solve division, conjugate and rationalization of denominator of surd

Instructional material: textbook and chalkboard.

Instructional techniques: question and answering.

Entry behavior: the students have learn how to solve surd.

Introduction: The Surds a+ $\sqrt{b}$ and a - $\sqrt{b}$ are said to be conjugate of one another. Thus conjugate of

a - $\sqrt{b}$ is simply obtained by changing the sign between the terms.

A and $\sqrt{b}$ to be opposite sign. Hence the conjugate of $-2\sqrt{5}+4\sqrt{7}$ is $-2\sqrt{5}-4\sqrt{7}$ and vise vesa conjugate surds are very useful in rationalizing denominators of problems in rational forms which have surds in their denominators.

Instructional procedure: Step1: the teacher will explain and solves an example such as. Find the product of the follow surd with conjugate $\sqrt{y}+2x$

The conjugate of $\sqrt{y}+2$ is $\sqrt{y}-2 \Rightarrow \left(\sqrt{y}+2x\right)\left(\sqrt{y}-2x\right)= y-4\,\mathrm{x}^2$

$= (5 + 3)\sqrt{2} \quad = 8\sqrt{2}$

Step2: the teacher will solve as follows. Simplify: $\frac{1}{6+\sqrt{2}}$

$$\frac{1}{6+\sqrt{2}} = \frac{1}{6+\sqrt{2}} \times \frac{6-\sqrt{2}}{6-\sqrt{2}} = \frac{6-\sqrt{2}}{36-2} = \frac{6-\sqrt{2}}{34} = \frac{3}{17} - \frac{\sqrt{2}}{34}$$

Step3: the teacher also solve division of surd. Evaluate $\frac{2\sqrt{3}+1}{5-\sqrt{3}}$. It should be noted that the problem is a division problem. Thus we sought first for the conjugate of the denominator ie $5+\sqrt{3}$ .then processed by rationalization.

$$\frac{2\sqrt{3}+1}{5-\sqrt{3}} = \frac{2\sqrt{3}+1}{5-\sqrt{3}} \times \frac{5+\sqrt{3}}{5+\sqrt{3}} = \frac{\left(2\sqrt{3}+1\right)\left(5+\sqrt{3}\right)}{\left(5-\sqrt{3}\right)\left(5+\sqrt{3}\right)}$$

$$= \frac{10\sqrt{3}+6+5+\sqrt{3}}{3\sqrt{2}+1} = \frac{11\sqrt{3}+11}{22} = \frac{1\sqrt{3}}{2} + \frac{1}{2}$$

Step4: the teacher call out some student to work some questions on the chalkboard and correct where is necessary.

Performance assessment (Evaluation): the teacher issue the student some questions to solve in the class

Conclusion: the teacher conclude his lesson by cheering the student while supervising their activities.

Appendix L

Software Package for Social Science

(1) T-Test [DataSet0]

Group Statistics

	Factor1	N	Mean	Std. Deviation	Std. Error Mean
Ttest1	1	43	13.6744	2.34745	.35798
	2	38	14.0000	2.78024	.45101

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ttest1	Equalvariances assumed	1.547	.217	-.571	79	.569	-.32558	.56981	-1.45977	.80861
	Equal variances not assumed			-.565	72.838	.574	-.32558	.57582	-1.47323	.82206

(2) T-Test

[DataSet0]

Group Statistics

	Factor2	N	Mean	Std. Deviation	Std. Error Mean
Ttest2	1	43	13.6744	2.34745	.35798
	2	49	10.8980	5.10410	.72916

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ttest2	Equal variances assumed	1.071	.304	3.274	90	.002	2.77646	.84792	1.09192	4.46100
	Equal variances not assumed			3.418	69.325	.001	2.77646	.81229	1.15611	4.39681

(3) T-TestGroup Statistics

	Factor3	N	Mean	Std. Deviation	Std. Error Mean
Ttest3	3	38	14.0000	2.78024	.45101
	4	49	10.8980	5.10410	.72916

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ttest3	Equal variances assumed	.197	.658	3.375	85	.001	3.10204	.91902	1.27478	4.92930

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ttest2	Equal variances assumed	1.071	.304	3.274	90	.002	2.77646	.84792	1.09192	4.46100
	Equal variances not assumed			3.618	77.112	.001	3.10204	.85737	1.39484	4.80924

(4a) T - Test

Group Statistics

	factor	N	Mean	Std. Deviation	Std. Error Mean
Data	male	25	14.08	2.326	.465
	female	18	13.11	2.324	.548

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Data	Equal variances assumed	.012	.912	1.348	41	.185	.969	.719	-.483	2.420
	Equal variances not assumed			1.348	36.808	.186	.969	.719	-.487	2.425

(4b) **Group Statistics**

	factor	N	Mean	Std. Deviation	Std. Error Mean
Data	male	26	14.23	2.597	.509
	female	12	13.50	3.205	.925

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Data	Equal variances assumed	1.086	.304	.749	36	.459	.731	.976	-1.249	2.710
	Equal variances not assumed			.692	17.951	.498	.731	1.056	-1.489	2.950

(5) NPar Tests [DataSet0]

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Kurs	130	53.1615	10.60847	21.00	80.00
Factor5	130	2.0462	.84323	1.00	3.00

Kruskal-Wallis Test

Ranks

	Factor5	N	Mean Rank
Kurs	1	43	80.78
	2	38	53.89
	3	49	61.09

Ranks

	Factor5	N	Mean Rank
Kurs	1	43	80.78
	2	38	53.89
	3	49	61.09
	Total	130	

Test Statistics[a,b]

	Kurs
Chi-Square	11.376
df	2
Asymp. Sig.	.003

a. Kruskal Wallis Test

b. Grouping Variable: Factor5