UNIVERSITY OF EDUCATION, WINNEBA

INVESTIGATING EFFECTS OF THE USE OF ACTIVE PEDAGOGY ON SENIOR HIGH SCHOOL STUDENTS' ACHIEVEMENT IN LOGICAL REASONING IN WEST MAMPRUSI DISTRICT

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DECLARATION

STUDENT'S DECLARATION

I, M. Sherif-Deen Yahaya, hereby declare that this write up, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is the result of my own original work and that no part of it has been submitted for another degree in this university or elsewhere either in part or whole.

SIGNATURE: ……………………… **DATE: ………………………**

SUPERVISOR'S DECLARATION

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

NAME OF SUPERVISOR: DR. JOSEPH ISSAH NYALA

SIGNATURE: ……………………… **DATE: ……………………**

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Many individuals and groups in various ways have made invaluable contributions to this study from its inception to conclusion. No work of this nature could be attributed to the sole effort of a single person.

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DEDICATION

This work is dedicated to my family, friends and well-wishers who have supported me throughout my educational journeys, especially, my mother Hajia Zahara. Although determination and perseverance were essential characteristics needed in order to complete this work, a supportive and loving family, friends and well-wishers made the entire process practicable, they instilled in me the passion that powered my desire for the completion of this work.

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ABSTRACT

The present study investigated effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning in the West Mamprusi District (WMD) of the North East Region of Ghana. The study employed a Quasi-experimental design with pre-test post-test control groups design which involved a sample of three hundred and forty (340) students from the four Public Senior High Schools of the district, using convenience and purposive sampling techniques. Observation, Achievement Test and questionnaire were instruments used for data collection. The results from the data indicated that most mathematics teachers in the West Mamprusi District use traditional teaching method in their classrooms. Analysis of students' pre-test scores of both treatment and control groups gave $F(1,338)= .542$ and $p\text{-value} = .462$ and $Effect\ size(\eta^2) = 0.077$, which indicates that before the intervention, students from the control groups and the experimental groups were on the same level of achievement in logical reasoning. While the post test scores of both treatment and control groups gave $F(1,338)= 15.131$ and $p\text{-value} = .000$ and $Effect\ size(\eta^2) = 0.421$, which showed that the active pedagogy teaching approach was significantly better than the traditional teaching approach in enhancing students' achievement in logical reasoning. The researcher therefore recommended that the Curriculum Research Development Division (CRDD) of the Ghana Education Service in collaboration with the related agencies in the Ministry of Education should organize in-service training for SHS teachers on the effective implementation of Active Pedagogy.

CHAPTER ONE

INTRODUCTION

1.0. Overview

This chapter presents the introductory section of the study which includes the background of the study, statement of problem, purpose of the study, research objectives, significance of the study, research questions and hypothesis, limitations and delimitations of the study, organizational plan of the study and the operational definition of key terms.

1.1. Background of the Study

The background of any study identifies and describes the history and nature of a well-defined research problem with reference to the existing literature. It should indicate the root of the problem being studied, and report in appropriate context, the problem in relation to theory, research, and/or practice, its scope, and the extent to which previous studies have successfully investigated the problem (Thomas & Hodges, 2010).

Centuries ago, the world discovered one of the most powerful and fascinating instruments not only for problem solving but also for formulating and predicting precisely the laws of nature. Today, every field depends on it for its growth; to the health scientists, it is mathematical statistics; to the physicists, it is mathematical physics; the engineers, it is mechanics; the cosmologists, it is mathematical modeling; the businesses, it is decision mathematics; just to name a few. This instrument is mathematics. Mathematics occupies a crucial and unique position in human societies and represents a strategic key in the development of the whole of mankind. The ability to compute, related to the power of technology and to the ability of social organization, and the geometrical understanding of space-time, that is, the physical world and its natural patterns show the role of mathematics in the development of a Society (Schoenfeld, 2002). According to Onivehu and Ziggah (2004), 'no nation can attain any technological breakthrough without well planned and effective implementation of mathematics education, since mathematics plays a leading and service role in all aspects of human endeavor' (p. 39).

The teaching and learning of mathematics is aimed at empowering people to learn to reason and make sense of the world around them as stated by Asiedu-Addo, Dontwi and Arthur (2004). Asiedu-Addo, Dontwi and Arthur asserted that mathematics is the means of sharpening the mind's reasoning ability and the overall personality of the individual studying it. More also, mathematics education is to enable learners understand, reason and communicate mathematically, and solve problems that might confront them in their daily life. Mathematics education is an excellent vehicle for the development and improvement of a person's intellectual competence in logical reasoning, spatial visualization, analysis and abstract thought. Students develop numeracy skills, reasoning, creative skills, and problem-solving skills through the learning and application of mathematics (Ministry of Education, 2010). These skills are valued not only in science and technology, but also in everyday living and in the workplace. The development of a highly skilled scientifically and technologically based manpower requires a strong grounding in mathematics. This perhaps suggests why mathematics is made a compulsory subject for all students at the secondary school level in Ghana. Knowledge of mathematics and the ability to use this knowledge is critical to the pursuits of many existing and newly emerging occupational fields. Research has shown that knowledge of mathematics at the basic and secondary level of education leads to increased opportunities for tertiary education (Buckley, 2009). It is for this reason that countries that want to grow scientifically put a great deal of emphasis on the study of mathematics at all levels of education. Due to the important role mathematics plays in the overall personal and intellectual development of its individuals, governments all over the world make conscientious efforts to make mathematics learning easy and to popularize its study (Nabie & Ngman-Wara, 2003).

In Ghana, for example, mathematics is a compulsory subject of study at all levels of pre-university education. Every student is required to pass in mathematics before he/she can proceed to the next educational level. At the Senior High School level in Ghana, mathematics education is to enable students apply the knowledge acquired in mathematics in their daily life and to recognize situations that require mathematical problem-solving strategies and apply their mathematics skills gained to resolve them. To many mathematical literates, mathematics is synonymous with solving problems. Indeed, one of the primary goals of mathematics education in Ghana is to develop students' ability to solve everyday problems (Ministry of Education, 2010). Mathematics teaching, therefore, essentially involves teaching the subject matter and the applications of the subject matter in real life. This is to help students develop everyday problem-solving skills. One of the biggest hurdles many students face in their academic careers is mathematics, a discipline that is intertwined with almost every natural and social science, as well as many health and business-related fields. In spite of this importance of mathematics, many students consider the subject difficult and want to avoid learning it in high schools, colleges and universities, there by restricting their range of career opportunities Smithers (2006). Fletcher (2008) attributes this problem of students to the pedagogy employed by teachers.

There are oodles of pedagogies that teachers and instructors practice. Some of these methods of teaching are found to be less effective, most specifically the direct instruction approach which is also called the traditional or transmission method of instruction (Richmond & Hagan, 2011). According to Fletcher, the traditional method of instruction discourages learners from engaging in higher algebraic thinking in mathematics lessons (Fletcher, 2008). Here, the instructors or teachers use direct instruction and posit themselves as experts on the topic, hence students feel that they do not have anything to add or contribute to the learning process. This type of instruction puts students into a more passive role that allows them to disengage from the material which practically lessens the likelihood of them engaging in higher level thinking about classroom content. Learning mathematics by this method is of little interest to the learner since procedures for solving mathematical problems are explained to them and lesson note are written for them to copy. Teachers only question learners in order to lead them in a particular direction or to check if they are following the taught procedure(s). It is not the case that traditional methods of instruction are not effective at all; it appears effective when short-term recall is required, but they are less effective for longer-term learning because they encourage rote memorization of disconnected rules which are often misapplied and quickly forgotten. Even though the traditional lecture approach has been said to be less effective (Richmond & Hagan, 2011), it remains the prevailing method for teaching mathematics at the basic, secondary and tertiary levels in most African countries, especially in the Ghanaian classrooms. Other pedagogies like, co-operative or small groups, peer tutoring, problem-base, enquiry-base, challenge-base to mention a few which are active pedagogies are found to be highly effective (Prince, 2004).

Numerous studies have demonstrated the efficacy and potency of active learning instruction over direct instruction (Poirier & Feldman, 2007; Warren, 2006; Yoder & Hochevar, 2005). Freeman, Eddy, McDonough, Smith, Okoroafora, Jordt, and Wenderoth (2014), tested the hypothesis that lecturing maximizes learning and students' performance. They meta-analyzed 225 studies that reported data on examination scores or failure rates when comparing student performance in undergraduate science, technology, engineering, and mathematics (STEM) courses under traditional lecturing versus active learning. They found that the average examination scores improved by about 6% in active learning sections, and that of students' in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning.

Many research analyses done on the effect of the continuous use of the active teaching method across the STEM disciplines indicate that, active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes, although its greatest effects can be felt in small classes. This is the largest and most comprehensive meta-analysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.

Laursen, Hassi, Kogan and Weston, (2013) also investigated the impact of Inquiry-Based Learning (IBL) which is one of the Active Pedagogy techniques on students' academic performance. They concluded that, student who are taught with IBL method made higher gains than their peers who are taught with non-IBL method across cognitive, affective, and collaborative domains of learning, they further stated the students who are taught with IBL method did well or better than their colleagues who are taught with non-IBL in subsequent mathematics courses, and finally, the IBL method had a strong positive impact on women's learning gains, confidence, and desire to persist when compared to non-IBL methods. This study also reported a significant difference in general academic performance between active pedagogy and the traditional teaching methods.

Thadani, Dewar and Breland, (2010) suggested that students must do more than just listening to the teacher's presentation: They must read, write, discuss, or be engaged in solving problems. Most importantly, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Within this context, it is proposed that strategies promoting active learning be defined as instructional activities involving students in doing things and thinking about what they are doing or reflecting on what they are doing (Thadani, Breland, & Dewar, 2015). The use of these techniques in the classroom is vital because of their powerful impact on students' learning. Knypstra and Prins (2009) have presented anecdotal evidence suggesting that active learning is effective. Christopher and Marek (2009), Ryan (2006), and Yoder and Hochevar (2005) have also presented evidence that students' exam scores are higher when taught with an active learning approach than when taught with more traditional approaches.

Nurjaman (2015), Kusumah and Minarti (2013) revealed that the implementation of active teaching strategies other than the conventional teaching method develop student's mathematical reasoning and enhance their achievements in mathematics as a whole. Tarmizi and Bayat (2012) made comparison of mathematical connection ability between students who study under Problem-Based Learning (PBL) Model and those under Guided Discovery Learning Model. The results of this study indicated that: there was no statistically significant difference in the achievement in mathematical connection ability between the students who studied under PBL model and those under guided discovery learning model.

There are some teaching approaches that may be termed as Active Pedagogy; Problem-based or case-based learning, Cooperative/collaborative learning/group work of all kinds, Think-pair-share or peer instruction, Inquiry-based learning, Discovery learning and Technology-enhanced learning. These approaches are sometimes used in literature to mean synonymously with Active Pedagogy since they encourage and engage students actively in the learning process. The extent to which these pedagogies are implemented determines their effectiveness or impact.

Ali and Mousa (2012) studied the impact of active learning strategies on second cycle students in an engineering course. They observed that when students understand and internalize concepts, their problem-solving skills development and promotion of academic success are enhanced. Thus, active learning strategies should start from the first year of studies through to higher education. Students who get traumatized when learning mathematics, turn out to be very disturbed, miserable and inattentive in a Mathematics class, it gets worse after being taught a topic and they later discover that they are unable to memorize, recall or apply the concepts in solving problems. NCTM (2010) identified the reasons for this difficulty as varying from one student to the other but may often be related to the teaching method being used.

Prince (2004) found that one major cause of senior high school student's poor performance in mathematics is the conventional (traditional) teaching and learning methods employed by teachers in the mathematics classroom. Prolonged use of this method has adverse effect on students in diverse ways. It does not promote academic achievement, retention and equity for all students in most cases. Hence the need to investigate the effects of the use of alternative teaching methods like active pedagogy which has been found to be effective in enhancing students' achievement in many fields including STEM.

Windia and Yaya (2015) found that the enhancement of mathematical representation ability of Junior High School Students through Discovery Learning was better than students who received conventional learning. The study confirms the importance of the enhancement of mathematical representation ability and concluded by making insightful suggestions and recommendations to stakeholders in education in helping students to enhance mathematical representation ability through discovery learning by the scientific approach.

For Ball and Bass (2003), although all the strands of reasoning are important and mutually influential, 'adaptive reasoning is the glue that holds everything together' (p. 129) in that, it allows for concepts and procedures to connect together in sensible ways, suggests possibilities for problem solving, and allows for disagreements to be settled in reasoned ways. Central to adaptive reasoning is the justification of claims and development of arguments. Literature suggests that there are two key practices involved in mathematical reasoning - justifying and generalizing and other mathematical practices such as symbolizing, representing, and communicating, are key in supporting these (Ball & Bass, 2003). Justifying is a key element of adaptive reasoning and to justify means 'to provide sufficient reason for'. Hence students need to be able to justify and explain ideas in order to make their reasoning clear, hone their reasoning skills and improve their conceptual understanding. For Ball and Bass

(2003), 'unjustified knowledge is unreasoned and, hence, easily becomes unreasonable' (p. 29). Justification is a key mathematical practice that allows mathematicians and mathematics teachers and learners to make connections between different ideas and parts of an argument, to provide warrant for claims and conjectures, to settle disputes, and to develop new mathematical ideas.

1.2. Statement of Problem

The rationale for teaching mathematics in Senior High Schools as stated in the mathematics curriculum in Ghana, is to consolidate gains made in the Basic School Mathematics and to raise standards of attainment by providing knowledge to enable all Ghanaian students acquire mathematics skills, insights, attitudes, and values they will need to be successful in their chosen careers and daily lives (Asare-Inkoom, 2005). In Ghana, students are expected to learn mathematics concepts while acquiring process skills, positive attitudes and values and problem-solving skills. For more than a decade now, various forms of researches have been conducted on a variety of teaching strategies for use in mathematics classrooms, ranging from teacher-centered approaches to more student-centered ones. The reason for this is to inform the stakeholders, curriculum developers and teachers on the teaching strategy that will:

i. Help arouse student interest and curiosity

ii. Sharpen students' thinking skills

iii. Demonstrate the application of theory to practice

iv. Enhance students' knowledge, skills, or attitudes

v. Prepare students for problem solving and not examination.

The background of this study has exposed the effectiveness of using Active Pedagogy on post-secondary and Senior High School students' achievements in various fields of study including, science, mathematics, engineering and technology. This can be realized from conclusions from the studies carried out by Knypstra and Prins (2009), Christopher and Marek, (2009), Ryan, (2006) and Yoder and Hochevar, (2005). However, from the same background we learned that Active Pedagogy can also be detrimental if it is not properly implemented, as reported by Pfaff and Weinberg (2009) as well as Weltman and Whiteside (2010).

Despite the fact that the background has named numerous studies suggesting the effectiveness of active pedagogy in the enhancement of students' achievement at various levels of education and in various fields especially mathematics, not much literature has been seen in Ghanaian context pointing to the effects of active pedagogy. It is not surprising that this method is not commonly practiced by Ghanaian teachers in the mathematics classroom (Kuwayama, Davis, Ampiah, & Kwabla, 2007).

1.3. Purpose of the Study

A purpose statement conveys the overall intent, aim or goal of research in a single sentence. It indicates what the researcher intends to accomplish and establishes the central direction for research (Creswell, 2002). This study is specifically carried out to investigate the effects of the use Active Pedagogy on Senior High School students' achievement in logical reasoning in West Mamprusi District (WMD) of the North East Region of Ghana. This will help improve students' academic achievement, their understanding of concepts in logical reasoning and further improve their attitude to learning mathematics.

1.4. Objectives of the Study

A research objective is a specific statement indicating the key issue to be focused on in a research study. Usually a research study will have at least one specific research objective and this research was not an exception. This study was designed to:

1. Examine the teaching approaches used by mathematical teachers in the Senior High Schools of the WMD.

2. Determine the initial achievement of Senior High School Students in logical reasoning by teaching approaches.

3. Investigate the effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning in the WMD.

4. Examine students' attitude towards the use of active pedagogy.

1.5. Research Questions

Research questions refer to the questions that the researcher seeks to answer. It also enquires about the relationship among variables that the investigator seeks to know (Thomas & Hodges, 2010). The study was designed to add to solving the problem of Senior High School students' achievement in logical reasoning, and was guided by the following questions:

1. What teaching approaches are used by mathematics teachers in the Senior High Schools in the WMD?

2. What is the achievement of Senior High School students by teaching method in logical reasoning in the WMD?

3. What is the effect of Active Pedagogy on Senior High School students' achievements in logical reasoning in the WMD?

4. What is students' attitude towards the use of active pedagogy?

1.6. Research Hypothesis

H_o: there is no significant difference in the mean achievements between students' taught by the use of active pedagogy and those taught by the traditional teaching methods.

1.7. Significance of the Study

It was hoped that the findings of this study indicated the difference between the Active Pedagogy teaching approach and the conventional teaching method on the achievements of students in logic. It might therefore sensitize and provide the mathematics teachers with an alternative method of teaching logic for easier understanding and effective application by students. Furthermore, it might serve as an eye-opener for more research works on Active Pedagogy teaching method for teaching other identified difficult themes of further mathematics.

The findings might be of use to the curriculum planners, it might aid them in identifying essential elements of logic in further mathematics especially logic skills, concepts, values, application and appreciations that could be included in further mathematics curriculum. Its findings might also be used by ministries and department of education, supervisors and other researchers in seminars, conferences and workshops to improve the knowledge of teachers in pedagogy.

1.8. Delimitations and Limitations

1.8.1. Delimitations

The delimitations are those characteristics of a study that arise in limiting the scope of the study (stating the boundaries) and by the conscious exclusionary and inclusionary decisions made during the development of the study plan (Simon & Goes, 2013). Delimitations arise from the specific choices made by the researcher. This current study was delimited as follows;

1. The study considered final year senior high school students in the West Mamprusi District of the East Region of Ghana.
2. Four (4) public senior high schools and one (1) private senior high school from the district were involved in the entire study.
3. Logical reasoning as a topic in mathematics was selected for the study. This covered statements, negation of statements, simple and compound statements, conjunction and disjunction of statements, conditional and bi-conditional statements, equivalent statements, tautology and contradiction of statements, and the truth table.
4. A two (2) day workshop was organized for two (2) mathematics teachers to educate them on how to apply the intervention (active pedagogy lesson plan) in their class room.
5. A sample of two hundred and forty (240) students in total were involved in the study.

1.8.2. Limitations

According to Simon and Goes (2013), limitations are the shortcomings, conditions or influences that cannot be controlled by the researcher and which place restrictions on the methodology and conclusion. The following were the limitations of the study:

1. The students selected were offering different programs. This means that they come into the study with different previous knowledge.
2. Most of the students are not accustomed to group work and so the use of active pedagogy may pose a little problem at the beginning.
3. Since the classroom will be made of several small groups, the noise level will escalate beyond the normal class lessons and can cause problem for the teacher as well as those who have attention difficulties.
4. Some students may be absent at the beginning of the implementation of the intervention and will suddenly show up in the middle or somewhere at the implementation stage.

1.9. Organizational Plan of the Study

The study has been organized into five chapters namely Introduction, Literature Review, Methodology, Data Analysis and results and Conclusion and recommendation.

The first chapter presents the introductory section of the study which includes the background of the study, statement of problem, purpose of the study, research objectives, significance of the study, research questions and hypothesis, limitations and delimitations of the study, organizational plan of the study and the operational definition of key terms.

The second chapter is to review issues in literature concerning effective use of Active Pedagogy on Senior High School students' achievement in logical reasoning. It therefore presents some pertinent views from authorities in the field of mathematics education on the use of Active Pedagogy and students' achievement in relation to the learning of logical reasoning. The first part of the chapter discusses the general philosophical views of mathematics education and their influence on teachers' or instructors' professional practices. The second part of the chapter discusses the teaching approaches used by mathematics teachers in the Senior High Schools and the challenges to their implementation. The third part hashed out students' achievements in logical reasoning through the use of Active Pedagogy. Finally, the chapter concludes by looking at the effect of the use of Active Pedagogy on Senior High School students' achievements in logical reasoning.

The third chapter provides detailed description of the methodology that was employed in the study. It covers the overview, research design, population and the settings of the study, sample and sampling techniques, research instruments, data collection procedure, the method of data analysis and ethical principles.

The fourth chapter with the title data analysis indicates the data collected before and after the intervention, analysis of the information, discussions of the information and findings from the analysis of the pre- and post-intervention tests. It also puts the research in the domain of research.

The fifth chapter presents the summary of the study, conclusions based on the specific findings from the data analyzed and recommendations. The findings have been divided into three sections, each relating to the research question that underpinned the study.

1.10. Operational Definition of Key Terms

Instruction

Instruction is defined as a planned action, practice, or procedures for teaching.

Teacher-Centered Instruction

A process whereby the teacher controls and directs how and what students learn. Ormrod (2004) described a teacher-centered instruction as instruction 'in which the instructor directly presents the material to be learned - for instance, through lectures, explanations, and textbook' (p. 241). Ormrod emphasized that the teacher is the major provider of information in this type of instruction.

Student-centered Instruction

Ormrod (2004) described a student-centered instruction as instruction that 'encourages students to construct their own knowledge and understanding through Discovery learning, whole-class and small group discussions, cooperative learning, and group problem-solving activities are all examples of student- centered instruction' (p. 242). This is also called student-centered, child-centered, or learner-centered to properly describe instruction where students direct their own learning and learning activities with the teacher as guide or facilitator.

Instructional Strategy

This is the daily transactions that occur between teachers and students which lead to the attainment of the identified outcome. These transactions should include multiple materials, techniques, and activities supported by modeling, intensive coaching, supervised practice, and monitoring.

Problem-Based Learning

Problem-Based Learning (PBL) teaching method uses problems as a base to motivate student learning of knowledge and skills. In the PBL teaching method, students encounter a problem or dilemma and use an organized, logical method to solve the problem. This method of teaching is a student- centered and inquiry-based. According to Schwartz, Mannin and Webb (2001), in a standard PBL classroom, students will work in small groups, and the teacher is a catalyst for learning and guides students through the problem-solving process rather than merely acting as a dispenser of knowledge (Dobbs, 2008).

Inquiry Learning

Answering and solving problems by analyzing data and creating and testing theories and hypotheses to expand the conceptual system with which one processes information (McNergney & McNergney, 2009).

Active Learning

A learning strategy in which participants are actively involved in the concepts of knowledge, activity, and reflection of information.

Teaching styles

Teaching styles have been defined as the range of practices by which a teacher can operate and accomplish certain objectives. Teaching style research has found that teachers demonstrate patterns of beliefs that guide their instructional choices.

Conventional classroom teaching style

1. Teacher explains, illustrates, demonstrates, gives notes on procedure and solves examples for students to copy.

2. Students do exercises and homework or assignment individually.

3. Teacher uses questioning to get feedback from students and students are hardly ask to justify their answers.

Problem Based Classroom Teaching Style

1. Teacher explains, illustrates, demonstrates, gives notes on procedure and solves examples for students to copy.
2. Teacher task students to discuss a give problem, debate about it and above all justify their results.
3. Students do exercises and homework or assignment in groups.
4. Teacher uses questioning to get feedback from students

Active Pedagogy Classroom Teaching Style

1. Teacher task students to discuss a give problem, debate about it and above all justify their results.
2. Students do exercises and homework or assignment in groups.
3. Teacher uses questioning to get feedback from students
4. Peer-led, think, pair and share.
5. Student's dominates classroom discussions by engaging in case study, take part in cooperative learning.

Student's Logical reasoning achievement

The student's demonstration of skill and knowledge acquisition in logical reasoning, this was assessed through the use of the student's scale score in the logic achievement test(LAT).

CHAPTER TWO

LITERATURE REVIEW

2.0. Overview

This chapter is to review issues in literature concerning effective use of Active Pedagogy on Senior High School students' achievement in logical reasoning. It therefore presents some pertinent views from authorities in the field of mathematics education on the use of Active Pedagogy and students' achievement in relation to the learning of logical reasoning. The first part of the chapter discusses the general philosophical views of mathematics education and their influence on teachers' or instructors' professional practices. The second part of the chapter discusses the teaching approaches used by mathematics teachers in the Senior High Schools and the challenges to their implementation. The third part hashed out students' achievements in logical reasoning through the use of Active Pedagogy. Finally, the chapter concludes by looking at the effect of the use of Active Pedagogy on Senior High School students' achievements in logical reasoning.

2.1. Philosophical Views and Professional Practices in Mathematics Education

There is absolutely no doubt that the view that mathematics teachers or instructors hold about the philosophy of mathematics influence their professional practice, Ernest (2013) discussed the foundations of mathematics and present a number of philosophies. Among these are the three major philosophies of mathematics which dominated the 'foundations' debate in the early part of the twentieth century. These philosophies are Platonism, Formalism and Constructivism.

2.1.1 Platonism

Platonists believe that mathematical objects exist and that their existence is an objective fact quite independent of our knowledge of them. These objects, they claim, are real definite objects with definite properties, some known, and some unknown, (Fletcher, 2008). In other words, any meaningful question about a mathematical object has a definite answer, irrespective of the fact that we are able to determine it or not. A teacher who holds this philosophical view is an empirical scientist. He cannot invent anything because he believes it is already there. All he can do is to discover them, a Platonist, calls on mathematicians to affirm that mathematical forms indeed have an existence that is independent of the mind considering them. In other words, mathematical knowledge is 'neutral', culture-free and absolute. Hence a teacher with this philosophical view can lead students to believe that mathematics is inflexible, lacking creativity and fun.

2.1.2. Formalism

Formalists, on the other hand, do not believe in the existence of mathematical objects. They believe that mathematics just consists of axioms, definitions and theorems. They see mathematics as a science of rigorous proofs. Any logical truth must have a starting point - the axiom upon which the theorem is built. The axioms may be false or true but, to the formalist, that is not important. What is important is the valid logical deduction that can be made from the axiom. Perhaps the most influential example of formalism as a style in mathematical exposition was the writing of Bourbaki, which had a tremendous influence all over the world in the 1950s and 1960s (Fletcher, 2008). This period marked the construction of 'modern mathematics' as an academic content unified by the set of theoretic ideas (Noss & Dowling, 1990).

Hence a teacher with this philosophical view will surely lead students to believe that mathematics is made up of abstract, irrelevant and difficult concepts.

2.1.3. Constructivism

A radically different alternative to both platonism and Formalism is constructivism. Constructivists believe that mathematics does not grow through a number of indubitable established theorems, but through the incessant improvement of guesses by speculation and criticism. Lakatos (1980), for example, argued that mathematics is not infallible and like all the natural sciences, it too grows from criticism and correction of theories which are never entirely free of ambiguity or the possibility of error or oversight. Starting from a problem, there is a simultaneous search for proofs and counter examples. New proofs explain old counter examples; new counter examples undermine old proofs. Constructivism thus allows students to construct their own understanding of mathematical concepts, so that the primary role of teaching is not to lecture, explain, or to transfer mathematical knowledge, but to create situations for students to make the necessary mental constructions. A teacher with this philosophical view can help arouse student interest and curiosity, sharpen their thinking skills, enhance their knowledge, skills, or attitudes and prepare them for problem solving.

In spite of the inability of any of these philosophies to establish an 'undisputed' foundation of mathematics, they have very important implication for mathematics education not only because of the link between pedagogy and philosophy of mathematics, but the aims of mathematics education are influenced by these philosophies (Fletcher, 2008). For example, Platonists view mathematics as a set of indubitable truths, a supreme achievement of humankind and an intrinsically valuable treasure. Based on these values, the main aim for mathematics education is the transmission of mathematical knowledge as a good in itself. In other words, mathematical knowledge is good because it trains the mind and not because it is used in our everyday lives. Indeed Plato (1941, p.23) cited in Fletcher (2008), believed that the pure disciplines such as mathematics had the power of turning the soul's eyes from the material world to the objects of pure thought. It is perhaps no exaggeration to suggest that mathematics education in Ghana is heavily influenced by Platonism and Formalism although the perceived usefulness of mathematics is one of the most popular reasons cited by Ghanaian mathematics teachers for the teaching and learning of mathematics in schools (Fletcher, 2008).

Indeed, irrespective of the level at which mathematics is taught, the role of the Ghanaian mathematics teacher has almost always been that of a lecturer and explainer, communicating the structure of mathematics 'systematically'. The teaching style is simple. The teacher explains, illustrates, demonstrates and in some cases gives notes on procedures and examples. The pupils are led deductively through small steps and closed questions to the principle being considered. A common pattern, particularly with lower attaining pupils, is to show a few examples on the chalkboard at the start of the lesson and set similar exercises for the pupils to work on their own. At its best, and given pupils who are sufficiently motivated, this style of teaching achieves what it is set out to do - that is, prepare the pupils for examinations. At the worst, it becomes direct 'telling how' by the teacher, followed by in comprehension on the part of the pupils. What is lacking in this approach, even at its best, is a sense of genuine enquiry, or any stimulus to curiosity or appeal to the imagination (Ernest, 2013). Accepting this view of mathematics implies a tendency to bring pupils to see mathematics as a deductive process. Here it is the method that is of central significance, and provided that it is thoroughly taught, learned and tested by repeated exercises, mathematics is thought to be 'successfully' conveyed. In terms of assessment, this view of mathematics overemphasizes summative assessment through external examinations at the expense of formative assessment, as competition in examinations in seen as providing a means of identifying the 'best' mathematician (Ernest, 2013). Indeed, it is the belief of many Ghanaian teachers that the best preparation for examinations is direct practice of the kind of questions that are eventually asked (Kanbogtah, 1999). It is therefore hardly surprising that the examination system in Ghana tends to drive the school curriculum instead of being informed by the latter. If a topic is never to be examined by the examination body, it is never taught! Amongst (mathematics) educators there is now considerable skepticism about the above perspective of mathematics, though institutionally, it remains a powerful lobby.

Surely, if mathematics education is about the overall development of the growing human being, as it should be, then other factors such as the development of the child's creativity are important. These factors may be better achieved through the development of the child as an autonomous enquirer and knower of mathematics and the fostering of the child's confidence, positive attitude and self-esteem with regard to mathematics, than through the learning of theorems and formulae in mathematics. Adopting the constructivist philosophy of mathematics education appears to be the way forward.

In constructivism, teachers and pupils are viewed as active meaning makers who continually give contextually based meanings to each other's words and actions as they interact. From this perspective, mathematical structures are not perceived, intuited or taken in but are constructed by reflectively abstracting from and re-organizing sensor motor and conceptual activity. Thus, the mathematical structures that the teacher 'sees' are considered to be the product of his or her own conceptual activity and could be different from those of the pupils (Von Glasserfield, 1995). Consequently, the teacher cannot be said to be a transmitter of such structures nor can he or she build any structures for pupils. The teacher's role here is viewed as that of a 'consultant architect'. Without overplaying the above metaphor, an architect must know the site or ground on which the structure will be built and must know in some detail the nature of the structure to be built and the theories which underlie the soundness of such structures. In the case of the mathematics teacher, he or she must know the nature of the current mathematical knowledge base of the student, and must have insights into the knowledge structures which can grow from such a base. The term 'consultant' has deliberately been appended to the term 'architect' (in characterizing the teacher's role) to suggest that the individual pupil is in charge of his or her knowledge building. The teacher provides ideas, activities, insights and feedback which should help the pupil build this knowledge. But how can the teacher communicate these ideas if he or she does not have the same mathematical structures as those of the pupils? How can constructivism explain a situation in which the pupil „understands' what is being „taught' if the teacher and the pupil construct their own mathematical meanings?

Fletcher (2008) argues that although instruction clearly affects what pupils learn, it does not determine it. Pupils are not passive recipients of knowledge; they interpret it, put structure on it and assimilate it in the light of their own framework. Jaworski (1994) also explains that the reason for successful communication between teachers and pupils is that teachers and pupils can negotiate meanings of actions and words as they interact. Consequently, teachers and pupils may share meanings of actions and words not through transmission of knowledge but through 'negotiation'. Perhaps, one reason why the constructivist paradigm should be seriously considered as an alternative to the transmission view instruction is that a fundamental goal of mathematics instruction is, or should be, to help students build structures that are more complex, powerful and abstract than those they possess before instruction. The teacher's role here cannot be merely to convey to pupil's information about mathematics but to facilitate profound cognitive restructuring through negotiation of meanings of mathematical activities. A number of researchers (Simon & Schifter, 1993) have reported findings which seem to confirm that the constructivist approach can lead to better communication of mathematical ideas by pupils. For example, Simon and Schifter (1993) studied the effects of a constructivist - oriented in-service program for teachers on their students' learning of mathematics. The researchers found that, along with transformations in the nature and quality of mathematics activity in the classroom, students' beliefs about learning mathematics changed and their attitudes towards mathematics improved. The students involved in the research were encouraged to discuss their mathematical problems and solutions among themselves. In other words, emphasis was placed on encouraging students to verbalize mathematical thinking, to explain and justify mathematical solutions and to learn to resolve complicating points of view. Focusing on the ways and processes by which pupils construct their own mathematics or mathematical realities; constructivism attempts to demystify mathematics and make it more accessible to all pupils. This process may be facilitated by encouraging pupils to pose and solve mathematical problems in social contexts and to discuss mathematics embedded in their own lives and environments. Indeed, if pupils are to be empowered and given greater control over their own lives, then as (Fletcher, 2008) points out, they should be encouraged to choose their own areas of study in mathematics and should also be encouraged to work in groups and generate mathematical problems.

There are a thousand possible ways through which learners' process incoming information from the environment. It is believed that most people favor some particular method of interacting with, taking in, and processing stimuli or information thereby exhibiting distinctive behaviors suitable to allow them to learn. For quite some time now, educators in all fields are becoming increasingly aware of the critical importance of understanding how individuals learn perhaps because this impacts the teaching strategies, academic performance and learning outcomes (Brady, 2013; Tulbure, 2012). Learning styles refer to how individuals process, focus, make information meaningful, and gain new information in order to translate it into building new skills. Fardon (2013) further views learning styles as a stable preference that is used by individuals to effectively organize, then process and develop their understanding of any learning challenge, task or situation thus adding an element of 'stability' in his definition. The general consensus here is that there exists a multitude of learning styles.

Similarly, just as the learners learn in different ways, so also teachers teach in different ways. In fact, effective teaching requires flexibility, creativity and responsibility in order to provide an instructional environment able to respond to the learner's individual needs (Tulbure, 2012) and the attainment of good academic achievement and educational outcomes (Fayombo, 2014) Moreover, most students learn best when the style of presentation is aligned with their preferred learning style. It is important for teachers to understand the students' learning styles and also for students to understand their own learning styles. By understanding different learning styles, teachers may gain insights into ways of making academic information more accessible to diverse groups of learners and an increased awareness of individual learning styles can help educators impart new information in a memorable way (Brady, 2013). Likewise, if students are aware of their preferred learning styles they will be able to recognize their strengths and weaknesses, by doing this, they can then develop strategies for effective learning.

However, one of the persistent challenges and problems that university teachers are facing is related to matching the teaching strategies with the students' learning styles for effective learning. Though teaching is a useful means of transmitting and sharing knowledge, it does not however always result in learning; this can be seen clearly in the painful disparity between what we think we have effectively taught and what students indicate they have learned on the examination papers. Is it possible to identify the most appropriate teaching strategies for each learning style? If yes, can matching these two learning-related concepts result in improved student academic achievement and learning outcomes? These and more are the concerns of the present study. It is expected that instructions developed with an awareness of different learning styles may help improve the information assimilation and learning experiences of the students.

In the past, research on learning and teaching in universities has focused on the teacher's behavior rather than the learners. However, some studies indicate that what the students do in order to learn such as adopting different methods of interacting with the learning materials is of greatest importance (Akdemir & Koszalka, 2008). As a result, educators have developed 'learner-centered' or 'student-centered' pedagogy that has significantly influenced our understanding of university learning and teaching (Fayombo, 2015; Yoder & Hochevar, 2005). These strategies include: brainstorming, case studies, debates, discussions, flipped classroom/blended learning, group work, questioning, simulations, role plays, games, video simulations among others utilized to actively engage learners in the learning process and achieve educational outcomes.

Some investigators confirmed that the alignment of teaching strategies and learning styles has a positive impact on the academic achievement of students. For example, Tulbure (2012) found significant differences between the achievement scores obtained by three categories of learners (convergers, divergers and accommodators) from two faculties of a Romanian University after the cooperative learning strategy was implemented. Similarly, Damrongpanit and Reungtragu (2013) reported significant differences between different matching conditions of students' learning styles and teachers' teaching styles after comparing the academic achievement of 3,382 ninth-grade students. In addition, Al-Saud (2013) revealed a significant difference in the mean values of GPA in relation to the first-year dental students' learning style preferences with students who have a single learning style preference having a lower mean GPA than those with multiple (quad-modal) learning style preferences. Evidence also abounds that matching teaching strategies and learning styles has a positive impact on the academic achievement and learning outcomes and that the match of teaching and learning styles in tertiary learners' second language acquisition can effectively improve students' achievement (Arthurs, 2007); motivation (Bell, 2007) and attitudes toward learning. On the other hand, a number of studies have revealed that matches between students' learning styles and instructional strategies did not affect the students' learning performance (Akdemir & Koszalka, 2008; Fardon, 2013; Micheal, 2006).

Thus, the issue of matching learning styles with teaching strategies and the effect on academic performance continues to be inconclusive, hence there is need for further investigation. Previous research findings suggest that the match of teaching and learning styles will promote the learning and educational effectiveness. 'If the two types of styles are consistent, it's obvious that the teacher's teaching styles match with the students' learning style, otherwise, they mismatch or unmatched' (Li, 2012).

2.2. Theoretical Framework

It is important to understand the theory under which Active Pedagogy is built; fundamentally there are two theories of learning, behaviorism and constructivism. Active learning is based on a theory of learning called constructivism, which emphasizes the fact that learners construct or build their own understanding (Dowling, 1990). Learning is a process of making meaning. Learners replace or adapt their existing knowledge and understanding (based on their prior knowledge) with deeper and more skilled levels of understanding. Skilled teaching is therefore active, providing learning environments, opportunities, interactions, tasks and instruction that foster deep learning. This theory of learning (constructivism) further has several other approaches like Problem-based or case-based learning, Cooperative/collaborative learning/group work of all kinds, Think-pair-share or peer instruction, Inquiry-based learning, Discovery learning and Technology-enhanced learning, etc. all the above-mentioned approaches of learning are also known as active pedagogies (Prince, 2004).

2.3. Active Pedagogies and their impact on Students' Achievement

Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing (Prince, 2004). While this definition could include traditional activities such as homework, in practice active learning refers to activities that are introduced into the classroom. The core elements of active learning are student activity and engagement in the learning process. Active learning is often contrasted to the traditional lecture where students passively receive information from the instructor.

According to Eison (2010), active learning instructional strategies include a wide range of activities that share the common element of —involving students in doing things and thinking about the things they are doing. Active learning instructional strategies can be created and used to engage students in (a) thinking critically or creatively, (b) speaking with a partner, in a small group, or with the entire class, (c) expressing ideas through writing, (d) exploring personal attitudes and values, (e) giving and receiving feedback, and (f) reflecting upon the learning process.

Mohamad (2017) said: method of learning that students do most work, and use their minds effectively and studying ideas well, and are working to resolve the problems and apply what they have learned, leading to rapidly understand and enjoy their activities. Mohamad (2008) said, the techniques (active pedagogy) helps students to work more than just listening to a lecture or presentation submitted by the teacher to his students, the students will, practicing a variety of operations such as: the discovery and mental skills such as: critical thinking and reflection over the cognitive and scientific skills.

2.3.1 Using Active Pedagogy

For academic achievement, active learning techniques are no worse than traditional techniques and, in most cases, they are significantly better (Knypstra & Prins (2009); Christopher & Marek, (2009) & Ryan, (2006); Yoder & Hochevar, (2005). For high level learning outcomes, such as identifying concepts, analysis of problems, judgment and evaluation, active learning techniques that involve high student autonomy and participation in decision-making may be more effective than traditional individualistic techniques.

In other to implement active pedagogy in a class, the following key stages must be considered;

a. Assess Students' Prior Knowledge

This could be as simple as asking students, 'What do you know about (topic)?' and writing their responses on the board or you can give them a test. The goal is to find out what they already know (or think they know). The teacher creates buy-in for the students because they feel smart, and they can then tailor the lesson to the information students do not know or do not remember correctly.

b. Try Skills Grouping

Divide the class into groups based on what skills they need to practice – not forever, but for a class period or two, so they can focus on what they really need help with. Example, have a group that works on logic quantifiers, one on logic operators, and one on conditional statements.

c. Where Skill Grouping is not Possible

Put the students into a four or five member groups depending on your class size, and keeping in mind the male to female ratio of your class. Example, I had in my class a five (5) member groups with the 3:2 male to female ratio. Then introduce basic concepts or fundamental principles of your topic to the students by posing a constructed problem that forces them to reflect on these concepts. Example: what is wrong with these statements below?

d. Let them Teach Each Other

Set some guidelines and then let students teach each other. Encourage them to do interesting activities – write tests for each other, design review games, etc. and evaluate each group on the accuracy of their content, the creativity of their approach, and how well they work together as a team. This is also a great way to discover how to motivate students. This procedure is used cyclically to bring out the best from the students.

Discovery learning Approach

This approach to learning puts the students in the center of the learning process. it pertains basically to the cognitive aspect of learning; the development and organization of concepts, ideas and insights, and the use of reference and other logical processes to control a situation (Li, 2012).

Characteristics of Discovery Learning Approach

The discovery learning approach is inductive, it proceeds from specific skills acquisition to general ones, freedom is necessary in the discovery learning approach, the teacher helps the learners acquire knowledge which is uniquely owned by the learners because they discovered it. Centering on a series of problem-solving situations, the discovery learning approach, therefore, calls for active student involvement. It is student-centered as well as self-directed learning.

Teacher's Role in the Discovery Learning Approach

Patience is needed in this approach. The teacher does not pressurize his students but he gives them ample time to formulate the expected generalization. The teacher should not answer for the students; he can give clues and hints instead.

Windia and Yaya (2015) investigated students' mathematical representation ability through Discovery, they used quasi-experimental with nonequivalent control group design with a sample of thirty-five (35) and thirty-four (34) students for the experimental and control group respectively. The instrument used was mathematical representation ability test and the result showed the enhancement of mathematical representation ability of students who received the discovery learning with scientific approach was better than students who received conventional learning. The study confirmed the effect of the use of discovery learning approach for the enhancement of students' mathematical representation ability.

A similar research was conducted by Ummi and Dadan (2015) comparing mathematical connection ability between students who study under Problem-Based Learning Model and those who study through Guided Discovery Learning Model. Their purpose was to examine the difference of the achievement and the enhancement of mathematical connection ability between the students who studied under PBL model and those of under guided discovery learning model. A pretest-post-test quasi experimental design was used in their study and a mathematical connection ability test instrument was used for the data collection. The results of this study indicated: (a) a difference achievement in mathematical connection ability between the students who studied under PBL model and those of under guided discovery learning model; (b) a significant difference in enhancement of mathematical connection ability between the students who studied under PBL model and those of under guided discovery learning model.

Jarnawi (2015) also investigated the effects of two learning models: Problem Based Learning and Discovery Learning models and to find out which of these two learning models increases creative thinking ability of Junior High School Students. Using a scale of 100 for students' creative thinking ability. The study found that the mean creative thinking ability of students who studied under the problem-based learning model was 78.52 with standard deviation 13.09 while that of those who studied under the Discovery Learning model mean was 77.78 with standard deviation 19.00. For Problem Based Learning the mean is 0.69 (medium) with standard deviation 0.18, and for Discovery Learning the mean is 0.70 (high) with standard deviation 0.25. Inferentially testing showed that in level of significance 0.05 the achievement and the creative thinking increment of both groups are not significantly different. His research concluded that both models of learning have relatively similar potentials in increasing creative thinking ability of Junior High Student.

Inquiry Approach

The concept of inquiry refers to one's attempt to understand fundamental issues and concerns that may affect one's status in life. From the point of view of teaching and learning, the concept of inquiry gives premium to the process of discovering what may be of help in motivating and in facilitating proper accumulation of knowledge (Li, 2012).

Characteristics of Inquiry Approach

Its emphasis is placed upon the aspects of search rather than on the mere acquisition of knowledge. It addresses itself primarily to learning concepts, although an end product of any inquiry lessons may be production of a new idea of concept - or a new invention. It is the search for truth, information or knowledge. It pertains to research and investigation and to seeking for information by asking questions. This approach views a given discipline more as an attitude than as a body of knowledge or as a method. Emphasizing the affective aspects of learning, it uses both the content and processes as means toward the development of the qualities of the mind as curiosity, skepticism, intellectual honesty and the like. In using this approach, the questions should proceed from the very factual to thought-provoking questions – that is from the 'what' questions to the 'how' and 'why' questions (Li, 2012). More opportunities should be provided to students to respond to questions that call for analysis, interpretation, evaluation, and judgment. The inquiry approach simply calls for the use of systematic method of studying a problem so that solutions therefore be equally prepared and implemented.

Teacher's Role in Inquiry Approach

In the classroom, the teacher should be an active participant in bringing about working relationship among learners, which enhances functional interplay of ideas and actions. Teachers and learners alike should learn to make adjustments in undertaking activities geared towards the 'greatest good for the greatest number'. This approach encourages teacher to be open-minded, and to be gracious in accepting criticisms and challenges with an end in view of insuring the carrying out of school activities as planned.

Matthew and Kenneth (2013) also studied the achievement levels of two groups of senior secondary schools students who were taught a difficult concept in mathematics using two different methods; the Guided inquiry teaching method and the conventional teaching method. They used 25-items (20 objectives and 5 essay) type in mathematics test covering the algebra of logic in the four types of logic statements was administered on a sample of 197 students before and after the teaching. The results showed that the students who were taught logic using the Guided inquiry teaching method had better achievement scores than students who were taught using the conventional teaching method.

Rafiq and Siti (2015) conducted a research on the enhancement of the mathematical reasoning ability and self-regulated learning of junior high school student through inquiry learning with Alberta model. They used quasi experimental with Nonequivalent Control Group Design and a sample consist of 32 students in the experimental group and 30 students in the control group. They used mathematics reasoning ability test, self-regulated learning scale and observation sheet. The results showed enhancement of the student's mathematical reasoning ability through inquiry learning with Alberta model and the students who were taught by the inquiry method performed better than those students who were taught using the conventional learning method. However, the research found that the enhancement of the student's self-regulated learning that had been received inquiry learning with Alberta model is not significantly different with that had been received the conventional learning.

Ma'arif (2016) examined the relative impacts of three different models of learning (collaborative learning, traditional lecturing and process-oriented guided inquiry learning [POGIL]) on student performance and learning perceptions. In a controlled case study, his measured the learning outcomes of 57 undergraduates in a chemistry course taught by the different learning modules, using quizzes and exams as performance measures. In one academic quarter, the collaborative learning method was used exclusively whereas all three models were used subsequently in a second quarter by dividing up lectures into 4 different modules. Student quiz and exam outcomes indicated significant difference between collaborative learning and traditional lecturing ($P = 0.01$) but not within the active learning variants or POGIL versus traditional lecturing ($P > 0.05$), suggesting students performed best on content taught by collaborative learning. However, student engagement and higher-order thinking appeared to be higher under the POGIL module though both skills were also evident during the collaborative learning period. Based on the outcome of the present study, it was recommended that purely inquiry-based lectures should employ short-burst intermittent lecturing to overcome student resistance and negative perceptions.

Cooperative or Group Learning

Cooperative or group learning is an instructional strategy which organizes students into small groups so that they can work together to maximize their own and each other's learning. Numerous research studies in diverse school settings, and across a wide range of subject areas, indicate promising possibilities for academic achievement with this strategy. For example, advocates have noted that students completing cooperative learning group tasks tend to have higher test scores, higher self-esteem, improved social skills, and greater comprehension of the subjects they are studying (Kim, 2005). The end result of a curriculum unit or group task may emphasize academic achievement, cognitive abilities, or physical skills, but the instructor must describe in very unambiguous language the specific knowledge and/or abilities the students are to acquire and then demonstrate on their own.

Characteristics of Cooperative or Group Learning

Instructors should organize small groups of approximately 3 to 6 members so that students are mixed heterogeneously, considering academic abilities, ethnic backgrounds, race, and gender. Students should not be allowed to form their own groups based on friendship or cliques. The main advantages with heterogeneous groups are that students tend to interact and achieve in ways and at levels that are rarely found with other instructional strategies. They also tend to become tolerant of diverse viewpoints, to consider the thoughts and feelings of others, and to seek more support and clarification of various opinions. Positive interdependence, which means that tasks are structured so that students must depend upon one another for their group's success in completing and mastering the targeted objectives (Li, 2012).

Teacher’s Role in Cooperative or Group Learning

Instructors need to provide directions and instructions that contain in it clear, precise terms exactly what students are to do, in what order, with what materials, and when appropriate, what students are to generate as evidence of their mastery of targeted content and skills. These directions need to be given to the students before they engage in their group learning efforts. Instructor serves as a coach or facilitated who interacts with the group, as necessary, to keep it on track or to encourage everyone in the group to participate.

The ability of problem solving has a fundamental role in students’ academic performance and their construction of the concepts. Keeping this in view, the present investigation has been planned out to examine the effect of problem solving ability on the academic achievement of high school students. The descriptive method was adopted and a sample of 250 students (165 male, 85 female) studying in 10th class of high schools were selected using random sampling technique. In order to assess the Problem Solving Ability, Problem Solving Ability Test (PSAT) (2006) developed by Dr. L. N. Dubey was used. The findings of the study revealed that problem solving ability had a significant effect on academic achievement of high school students. It is further revealed that the female students performed better as compared to male students. However, no interaction effect of problem solving ability and gender was found on academic achievement of high school students.

Saha, Ayub and Tarmizi (2010) conducted a study on collaborative problem-based learning in mathematics, they examined the effectiveness of teaching using this approaches on the performance of the students. On the whole, the study showed that PBL, as a new approach, has significant influence on the students' performance.

Another work that supported the positive effects of PBL was a study conducted by Derry, Hmelo-Silver, Nagarajan, Chernobilsky, and Beizel (2006) on two groups of pre-service teachers in the technology-supported PBL in Educational Psychology course. The research was carried out in three semesters and there were consistently positive effects favoring the students in the PBL class on targeted outcomes. Chinnappan (2017) conducted a research on MBA students which randomly assigned to some conditions such as PBL-first, lecture-second or lecture-first, PBL-second for two different topics in Management. The results of this study showed that, there was no significant difference on measures of declarative knowledge between above condition, however students in PBL group constructed more integrative explanatory essays for the concepts that they had learned. PBL approach has also been applied successfully at secondary education. The results of a study carried out by Mergendoller, Maxwell and Bellisimo (2006) on high school economics students found that, students in the PBL course gained more knowledge compared to students in traditional course. Hence contemporary research on classroom instructional modes suggests that teaching models employing active learning strategies result meaningful learning over traditional, passive lectures. Active learning is a student-centered approach based on engaging students in activities and creating classroom environment that permit students' ownership of the learning process. This in turn results improved student performance, as measured by traditional tests, as well as creating positive student attitudes towards the learning process Ma'arif (2016). Moreover, because active learning strategies incorporate multiple learning styles, such strategies are consistent with educational models based on theories of learning and motivation.

2.4. Learning Logical Reasoning in Senior High Schools

The Curriculum Research and Development Division (CRDD, 2010) of Ghana designed the teaching syllabus for teaching and learning various subjects both at the junior high schools and senior High schools. The teaching syllabus for both core and elective mathematics for senior High schools has place the teaching and learning of logical reasoning at the second but last topic among the third year topics. This makes the chances of it being taught to be low. Logic is the backbone of critical thinking. It is extremely useful for uncovering error and establishing truth. According to Volker Halbach, Logic is the scientific study of valid arguments, it is compulsory for all rational beings because it allows us to test validity arguments and to distinguish correct from incorrect reasoning. The CRDD (2010), states the general objectives of studying logic as; the student will:

1. Appreciate the concepts of logical reasoning.

2. Apply the concepts to determine the validity of compound statements.

3. Draw valid conclusions from truth tables.

4. Apply the rule of logic to deduce valid conclusions from arguments in general.

5. Be able to convince others logically on the validity of statements made.

The science of logic set out to provide us with a sound theory of reasoning, but much of the time our ability to reason logically is hampered by language. It is argued that natural language and the language of logic follow two entirely different sets of rules. The problems that language brings to our capacity to be logical are associated with meaning, context, our cultural knowledge, and our ability to communicate through writing or conversation.

It is hard to imagine that inferences and deductions made in daily activity aren't based on logical reasoning. A doctor must reason from the symptoms at hand, as must the car mechanic. Police detectives and forensic specialists must process clues logically and reason from them. Computer users must be familiar with the logical rules that machines are designed to follow. Business decisions are based on a logical analysis of actualities and contingencies. A juror must be able to weigh evidence and follow the logic of an attorney prosecuting or defending a case: If the defendant was at the movies at the time, then he couldn't have committed the crime. As a matter of fact, any problem solving activity or what educators today call critical thinking, involves pattern-seeking and conclusions arrived at through a logical path.

Deductive thinking is vitally important in the sciences, with the rules of inference integral to forming and testing hypotheses. Whether performed by a human being or a computer, the procedures of logical steps, following one from another, assure that the conclusions follow validly from the data. The certainty that logic provides, makes a major contribution to our discovery of truth.

Several text books are recommended for the teaching of mathematics topics in senior High schools by the CRDD (2010), as follows:

i. Core Mathematics for Senior High Schools Books 1, 2, 3 and 4.
ii. Core Mathematics for West Africa Senior High Schools. Anest Co. Ltd., Accra Newtown, Ghana.
iii. Macmillan Senior Secondary Mathematics for West Africa. (Books 1, 2 and 3).
iv. Core Mathematics for Senior Secondary Schools.
v. J.E. Ankrah,, E. Harrison Nuartey Quarcoo, Global Series and Approacher's Series Joint Core Mathematics for Senior High Schools.

All these books treat the topic logical reasoning but unfortunately they fail to include the principles of reasoning, these principles helps students to avoid faulty reasoning. This decreases the understanding of the students and this further affects their achievement in reasoning.

2.5. Senior High School Students' Achievement in Logical Reasoning

Achievement is defined as a sequence of work, which rests on a prior acceptance of certain basic elements, concepts, and thought. It also means the degree to which a specific task is accomplished. Hence operationally to this research, it means the degree to which senior high students are able to accomplish a logical reasoning task.

Osarenren and Asiedu (2007) submitted that the reason for the continued poor performance of students in Mathematics could, among others, be attributed to the students' inability to think critically and logically analyze Mathematical concepts systematically. This further shows that Critical Thinking is an essential concept that is required to enhance performance in any subject especially in Mathematics.

According to Adegoke (2013), students' level of mathematics reasoning ability plays a major role in their attainment in mathematics. He made this statement after carrying out a survey on a sample of 240 Senior Secondary School One Students (Age 14-16 years) who were randomly selected from four senior secondary schools in Isokan and Irewole Local Government Areas of Osun State, Nigeria. He analyzed a 24-item Mathematics Reasoning Ability Test (MRAT) and a 36-item Attainment in Mathematics Test (AMT) constructed to explain the indicators of students' mathematical reasoning ability. Adegoke concluded that Senior Secondary School One Students between the ages 14-16 years have poor mathematical reasoning ability.

Ongcoy (2016) carried out a similar study, which aimed at determining junior high school students' logical reasoning abilities, and to determine also whether there is a significant difference in students' logical reasoning abilities according to their gender. By way of survey he used 150 randomly selected grade 10 junior high school students in the Province of Cotabato, Philippines who answered a Test of Logical Thinking (TOLT), he reported the following findings, a) The higher the reasoning ability of a person, the more productive he is, b) the ability of logical reasoning has an essential function in the academic performance of students and their construction of the concepts, c) most students incorrectly answered problems in probabilistic reasoning and least number of students correctly answered problems in proportional reasoning and combinatorial reasoning and, d) male and female respondents have equal performances in problems pertaining to combinatorial reasoning, controlling variables, correlational reasoning and probabilistic reasoning but female respondents are better in proportional reasoning than the male respondents. These findings suggest that junior high school and Senior High School students' achievement in logical reasoning is not encouraging.

Another study conducted by Agah and sule (2015) specially revealed that students' achievement in logical reasoning is low. This study examined the determinants of students' logical reasoning and mathematics achievement. Three factors; age, sex and class level were viewed as determinants of students' logical reasoning. Ex-post-facto research design was used and the sample size was 420 senior secondary school students were selected also the instrument used for data collection was 'Mathematical Reasoning Test (MRT)'. The findings revealed that; Senior High School students' achievement in logical reasoning is low and that, age and class levels determine students' logical reasoning in mathematics. It was recommended that age and class level should be given serious recognition in planning and organizing the mathematics curriculum.

Ahmad, Prahmana, Kenedi, Helsa, Arianil and Zainil (2017), conducted a study to examine the impact of Critical thinking on Performance in Mathematics among Senior Secondary School Students in Lagos State. He used Quasi-experimental design and a sample of 195 students and Mathematics performance test and Watson-glaser Critical Thinking Appraisal were used for the study. The study revealed that there was a significant difference in Mathematics performance test scores among the experimental groups. The study also found out that there was no significance gender difference in Mathematics performance test. Critical Thinking Skills was also an effective means of enhancing students' understanding of Mathematics concepts. It therefore recommended that in teaching Mathematics in secondary schools,

Critical thinking skills should be infuse in the curriculum of teachers' education so as to improve students' performance in Mathematics.

Nor'ain, Norashiqin, and Amalina, (2012) studied the relationship between scientific reasoning skills and mathematics achievement measured by students' responses to a series of novel problems. The results indicated the existence of a moderate positive correlation between the two variables. All participating students exhibited low levels of scientific reasoning. Despite this, students in the high-achievement group performed significantly better than their peers in the low achievement group in the mathematics test. The results suggest that while scientific reasoning is necessary, these set of skills may not fully explain the kind of reasoning that underpins mathematical problem solving among secondary students.

Abdulkadir, Abdullah and Lutfi (2013) carried out a study to investigate whether the logical thinking level of mathematics teacher candidates were being affected by the variables of grade level, graduated high school type, and gender. They used the survey design and sample of 99 mathematics teacher candidates and a group assessment of logical thinking (GALT) instrument developed for measuring logical thinking level. The GALT instrument included six sub-scales; conservational reasoning (4 items), proportional reasoning (6 items), controlling variables (4 items), combinational reasoning (3 items), probabilistic reasoning (2 items), and correlational reasoning (2 items). The results of their study indicated that the logical thinking level of mathematics teacher candidates were low and was significantly affected by the variables of grade level and high school type, but not by the gender.

Cornelius and Unwana-obong (2014) inquired about the relationship between masters students' academic performance with respect to their syllogistic, here a case study was to determine the M.Ed. students' syllogistic reasoning ability and their performance in an educational psychology course. They selected a sample of 159 Master's degree students in education were made to write Psychology of learning (EDU 612) examination. Two instruments, the semester examination for EDU 612 and a test on syllogistic reasoning were used to obtain data. They concluded that there was no significant difference due to gender in the syllogistic reasoning ability as well as the performance of the students in Psychology of Learning. Also, the students' syllogistic reasoning ability did not significantly influence their performance in Psychology of Learning.

2.6. Summary

In this conclusion section, it is significant to put it short for the longer discussions of this chapter. The literature unveiled some of the keys issues and practices that the Ghanaian classrooms need to implement if the interest of mathematics education in the Ghanaian's curriculum is to (a) help arouse student interest and curiosity, (b) sharpen students' thinking skills, (c) demonstrate the application of theory to practice, (d) enhance students' knowledge, skills, or attitudes, and (e) prepare students for problem solving not examinations. The literature states that the above benefits can be reaped when post-secondary and Senior High Schools teachers or instructors will adopt and effectively implement constructivism as the way forward.

It also exposed the weaknesses of the traditional or teacher-centered method of instruction which makes it less effective to stimulate student's interest and curiosity, enhance higher order thinking and student's achievement and only prepares the students for examination through route learning or learning by memorization. The literature again unwrapped Active Pedagogy as a pedagogical tool which has no unique definition either in popular use or in the research literature, but rather refer to classroom practices that engage students in activities, such as reading, writing, discussion, or problem solving, that promote higher-order thinking instead of the amalgamation of other instructional strategies. The effectiveness, benefits and challenges of this pedagogical tool were also highlighted. The literature finally gave the impression that Senior High School students' understanding of logical reasoning is very poor which lead to their low achievement in it and in mathematic as a whole since logical reasoning is the language of mathematics. Hence the researcher adopted Active Pedagogy as the appropriate teaching strategies to enhance senior high students' achievement in logical reasoning.

CHAPTER THREE

METHODOLOGY

3.0. Overview

This chapter provides detailed description of the methodology that was employed in the study. It covers the overview, research design, population and the settings of the study, sample and sampling techniques, research instruments, data collection procedure, the method of data analysis and ethical principles.

According to Creswell (2002), before beginning any research project, it is necessary to decide which methodology to use. Researchers use three primary methodology types: qualitative, quantitative and mixed methods. Within these broad categories, more specific methods which include an array of options, such as case studies, quasi experiment, cross sectional survey, survey, case report design-based research, action research and many more for the researcher to choose (Creswell, 2002).

3.1. Research Design

This study made use of quantitative methodology since the researcher sought to investigate effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning, the response variables are students' test scores and their attitude towards the use of active pedagogy lesson plane base on a five Likert scale which are both quantitative. The study also employed the Quasi-experimental design with Pre-test and Post-test Control Groups Design. A Quasi-experiment is an empirical study used to estimate the causal impact of an intervention on its target population with little random assignment to treatment or control group. This design is most suitable for this study, since the study sought to test the effect of an intervention (lesson plan inspiring active pedagogy) on students' achievement in logical reasoning and their attitude towards the use of Active pedagogy. Also the assignment of treatment and control group was based on observed pedagogies of mathematics teachers in the district. According to Creswell (2002), Quasi-experimental research shares similarities with the traditional experimental design or randomized control trial, but it specifically has little element of random assignment to treatment or control group. Instead, Quasi-experimental designs typically allow the researcher to control the assignment to the treatment condition, but using some criterion other than random assignment for example an eligibility cutoff mark (Phelps, Fisher, & Ellis, 2007).

3.2. Population of the Study

The population for this study was all final year students in the Public Senior High Schools of the WMD of the North East Region of Ghana. The District has only four (4) Public Senior High Schools and one (1) private Senior High Vocational school. The District was chosen as the setting for the study because the researcher has spent at least two years of his educational life there. He has also taught many vacation and remedial classes in which the majority of the students from these Senior High Schools in the district attended. Familiarity with the social and academic settings of the area was another reason for which this location was chosen.

3.3. Sample and Sampling Techniques

According to Cohen, Manion and Morrison (2007), factors such as expenses, time, and accessibility frequently prevent researchers from gaining information from the whole population. Therefore, they often need to obtain data from a smaller group or subset of the total population in such a way that the knowledge gained is representative of the total population under study. This smaller group or subset is the sample as observed by Cohen, Manion and Morrison (2007). The researcher inadvertently faced all these impediments for which reason convenience and purposive sampling techniques were employed for the study.

According to Teddlie and Yu (2007), Convenience sampling involves drawing samples that are both easily accessible and willing to participate in a study. In convenience sampling, units are preferred on the basis of easy accessibility and elements are selected on the basis of the researcher's personal judgment. The convenience sampling technique was used to select the region and district for the study. The North East Region and the West Mamprusi District was chosen because of its nearness to the researcher's hometown and his familiarity with the social and academic settings of the area. This reduced some of the financial constraint associated with the study.

Purposive sampling technique is a method of selecting units for example, individuals, groups of individuals, institutions based on specific purposes associated with answering a research question (Teddlie & Yu, 2007). This technique was used to select four (4) final year classes from the four (4) Public Senior High Schools of the district for the assignment of control and experimental groups. Here, mathematics teachers were observed during their lessons periods to ascertain the teaching activities they use in their classrooms. These teaching activities were then classified into active and traditional pedagogies. Hence two classes where active pedagogies were used on purpose were assigned the experimental group and two classes where traditional pedagogies were used were assigned the control group.

Three-hundred and forty (340) students were selected from the final year class, comprising of one-hundred and seventy (170) students for the experimental groups which represent 50% and one-hundred and seventy (170) students for the control groups which also represented 50% of the sample.

3.4. Research Instruments

Generally, there are various procedures of collecting data. According to Birmingham and Wilkinson (2014), research instruments are simply devices for obtaining information relevant to your research project. Research Instruments are measurement tools (for example, questionnaires, interviews or scales, tests etc.) designed to obtain data on a topic of interest from research subjects. Birmingham and Wilkinson (2014) however argued that, there is no single research instrument par excellence. They stressed that, research is not a 'one-size-fits-all' enterprise and therefore no single research instrument is inherently superior to the other, but some of them are more useful than others in specific cases.

There are myriad of tests which cover all aspects of a student's life and for all ages (young children to old adults). For example, Cohen, Manion and Morrison (2007) stated the following types of tests; aptitude, attainment, attitudes and values, performance, ability, achievement, higher order thinking, anxiety, motivation, interest, and many others. This study utilized diagnostic achievement test (see Appendix A) in an attempt to unveil students' initial achievement in logical reasoning. Similarly, an outcome achievements test was constructed to test the students' achievement after the intervention (see Appendix B). Again, the study employed observation as a research instrument in an attempt to answer research question one (1). The observation tool was constructed by the researcher to find out the teaching activities used by mathematics teachers in their classrooms (see Appendix C). These teaching activities were then classified into active and traditional pedagogies. Also, a questionnaire was used to find out students' attitude toward the use of the intervention (see Appendix D). Finally, active pedagogy lesson plan was adapted from Merrill Harmin and Melanie Toth (see Appendix E). This lesson plan was used to teach logical reasoning to students in the experimental groups.

3.4.1. Logic Achievement Test

Reasoning tests were first developed by Alfred Binet, a French educationalist who published the first test of mental ability in 1905 (Jeotee, 2012). Alfred Binet was interested in assessing the intellectual development of children, and eventually he developed the concept of mental age. The reasoning test was a part of an IQ test; the Stanford-Binet intelligence scales can be considered the first of all modern intelligence assessments. Reasoning skills test is a kind of psychological test which places emphasis on cognitive thinking and reasoning. Among many psychological tests, reasoning skills tests have been widely adopted.

The diagnostic as well as the summative logic achievement tests was used to ascertain the students' achievement in logical reasoning before and after the intervention respectively (see Appendix A and B). These test instruments were design in concordant with the West African senior School Certificate Examination structured questions given by the West African Examination Council and Assessment Board and also in tune with MOESS Mathematics Syllabus guidelines given by CRDD. The tests had only one section with fifteen (15) items, the items were designed to test students' achievement in specific concept in logical reasoning, that is, five (5) of the questions tested students' understanding on quantifiers, five (5) on conditional statements and five (5) on syllogism and relational reasoning (see Appendix A and B).

3.4.2 Observation

An observational tool was developed to assess the pedagogies used by mathematics teacher in the district. This was done by preparing a list of teaching activities that mathematics teachers use to engage their students during lessons (see Appendix C). There were six (6) items on this list each measuring a specific teaching technique.

3.4.3 Questionnaire

Questionnaires are doubtless one of the primary sources of obtaining data in many research endeavor. However, the critical point is that when designing a questionnaire, the researcher should ensure that it is valid, reliable and unambiguous (Richards & Schmidt, 2002). On the whole, questionnaires can appear in three types: closed-ended (or structured) questionnaires, open-ended (or unstructured) questionnaires, and a mixture of closed-ended and open-ended questionnaires. All of these forms are acknowledged to have their merits and demerits. The questionnaire was the third instrument used in this work to solicit students' attitude towards the use of active pedagogy teaching approach. It consists of sixteen (16) items with a 5-point Likert type scale: strongly agree, agree undecided, disagree, and strongly disagree. It consists of both positive and negative statements (see Appendix D).

3.5 Validity and Reliability of Instrument

3.5.1 Validity

Pallant (2005) described validity as when an instrument measures what it is supposed to measure. The content validity of the instruments was largely determined by the supervisor by making corrections and suggestions. Also the instruments were given to experts in the field of mathematics and mathematics education to evaluate the items for content, construct and face validity. After the necessary corrections were made the instruments were pilot tested on a selected group comprising Thirty (30) students. The participants of the piloted group did not take part in the actual study and were found valid and suitable for measuring the construct.

3.5.2. Reliability

The reliability of a research instrument is the consistency of the instrument in producing similar results given the same conditions on different occasions. The reliability of a scale indicates how free the instrument is from random error. One way of determining the reliability of an instrument is to assess its internal consistency, i.e. the degree to which the items that make up the scale are all measuring the same underlying attribute. The most commonly used statistic in determining internal consistency is the Cronbach's alpha coefficient (Pallant, 2005). This statistic provides an indication of the average correlation among all of the items that make up the scale with values ranging from 0 to 1, with higher values indicating greater reliability. The reliability value of the instruments was then calculated using the Cronbach Alpha, a feature in the SPSS software. The Cronbach Alpha value for the diagnostic and summative Logic Achievement Tests (LAT) were .79 and .83 respectively, that of the Active Pedagogy Questionnaire was .83. Since the average correlation among all of the items on all the instruments gave a Cronbach Alpha value greater than 0.7, we can conclude that all these instruments have high average correlation and hence are reliable for use.

3.6. Scoring the Test Items

The instruction given in the Logic Achievement Tests in the pretest and post-test did not lay emphasis on only the truth or falsehood of the questions, since this can easily be guessed out on 50% probability but it also tasked the students to logically explain their judgment.

The processes and the answers were scored as 45 correct in all if students were able to apply the right approach of solving the problems and zero if students were unable to apply the right approach of solutions. The test items were scored based on the number of processes involved in each item and since each item had exactly two processes (i.e. student's judgment on validity of the conclusion in a question and the explanation to their judgment). Hence one (1) mark was awarded to each correct judgment on the validity of the conclusion in a question and zero (0) otherwise. Similarly, two (2) marks was awarded to each correct explanation of the judgment and zero (0) otherwise. Therefore, each question attracted a minimum score of zero (0) and maximum score of three (3).

3.6.1. Piloting the Instrument

Pilot testing is a trial run of procedures and instruments that are planned to be used which may lead to a researcher making changes in an instrument based on the feedback obtained from a small number of individuals who complete and evaluate the instrument (Creswell & Guetterman, 2019). The main purpose of the pilot testing was to identify potential threats or problems before they become real obstacles to the success of the instrument and hence the study. The pilot test was conducted using a sample from the population that possessed similar characteristics as that of the targeted respondents of the study. Thirty (30) students comprising of twenty-one (21) male and nine (9) female students were used in the pilot study. The piloted instrument had twenty items in it; each fourth of the items measured a unique construct. The feedback of the respondents helped to polish off the quality of the instrument by taking away some of the items, and restructured the rest of the content of the instrument.

3.7. Data Collection Procedure

The student-researcher presented an introduction letter together with permission letter to the Headmasters of the selected schools who gave their approval for the research to be carried out in their respective schools (see Appendix F). The researcher was then introduced to the head of department (HOD) for mathematics of the selected schools who also introduced the researcher to some of the teachers from the mathematics department who were available. This was not done simultaneously. It was done on different days for four consecutive days. This ensured the full confidentially and co-operation of the teachers.

The student-researcher then stated observing mathematics teachers while they are delivering lessons. For one-week period, fifteen mathematics teachers were observed from all four public senior high schools. Three (3) mathematics teachers were then persuaded to take part in the research work. Two (2) of whom were observed using the tradition teaching approach and were therefore assigned to the control groups and one teacher who appeared to be using active pedagogy together with the researcher were assigned to the experimental groups.

Four (4) intact class where these teachers teach were used, two for the control groups and the other two for the experimental groups as seen from Table 3.1.

Table 3.2: Control and Experimental groups for the data collection procedure

	Group	Test 1	Intervention	Test 2
	1	Pre-test	No intervention	Post test
Control	2	Pre-test	No intervention	Post test
	1	Pre-test	Intervention	Post test
Experimental	2	Pre-test	Intervention	Post test

Each class were given the diagnostic logic achievement test (pre-test) before students were taught logical reasoning either by the traditional teaching approach (no intervention) or by active pedagogy approach (intervention). The response rate was hundred percent (100%) as the researcher directly administered test and was at hand to collect completed tests from respondents.

3.8. Ethical Issues

There are a number of measures adopted to try to protect the rights of the participants of the study. Firstly, the principle of voluntary participation was adopted to ensure that participants were not being forced into taking part in research. The researcher explained to the participants that their answers would not affect anything in relation to them and they could stop anytime they want. It is not compulsory. Meanwhile, permission to conduct the study was sought from the Headmasters of the schools that participated in the study. Ethical standards also require that researcher does not put participants into the situation where they might be at risk of harm as a result of their participation. Harm can be defined as both physical and psychological. There are two measures that were applied in order to help protect the privacy of the prospective participants.

Firstly, the researcher guaranteed the participants confidentiality; they were assured that identifying information would not be made available to anyone who is not directly involved in the study.

Secondly, the principle of anonymity was applied to make sure that the participants would remain anonymous throughout the study. The participants were not required to fill in their names when answering the tests or questionnaire.

3.9. Data Analysis Procedure

The study investigated the effects of the use of active pedagogy approach on Senior High School students' achievement in logical reasoning in the WMD, it took into consideration the teaching approaches employed by mathematics teachers in Senior High Schools in the District and by so, the study compared the achievement of students in logical reasoning by teaching approaches. The study sequentially collected quantitative data through tests, questionnaire and observation. The observation tool was used to identify mathematics teachers' teaching activities in their classroom settings, these teaching activities were grouped into teaching approaches that is either traditional teaching approach or active teaching approach. The questionnaire was used to capture students' attitude towards the use of active pedagogy lesson plan. The tests (pre-test and post-test scores) were carefully examined for completeness and accuracy of students' response verifying whether guidelines for responses were adhered to by participants. These were then coded and keyed into the SPSS for statistical tests specifically the analysis of variance (ANOVA) to ascertain the existence of statistically significant difference between the students' achievement in logical reasoning in the pre-test and post-test, this was also presented in a tables and graphs. In general, parametric tests are regarded as being more powerful than non-parametric tests in detecting the differences existing among the groups, but this statement is tenable only if four parametric assumptions are met: the normality, homogeneity of variance, interval data, and independence assumptions (Field, 2005). As the parametric tests assume the populations being examined are normally distributed and variances among the populations being compared are similar, the first two assumptions (i.e. the normality and homogeneity) could be checked by looking at the distribution of the sample data via the Kolmogorov Smirnov test (K-S test) and Levene's test respectively, which are addressed in the following section. The last two assumptions (i.e. the interval data and independence) could be examined by common sense. It is therefore essential to examine the assumptions before determining which statistical test (i.e. parametric or non-parametric test) is applied, given that using a parametric test when the assumptions are not satisfied will produce inaccurate results (Field, 2005).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0. Overview

The study investigated effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning; it took into consideration:

1. The teaching approaches used by mathematics teachers in Senior High Schools of the WMD.

2. The level of achievement of Senior High Schools students in logical reasoning by the teaching approaches before the intervention.

3. The effects of active pedagogy on Senior High Schools students' achievement in logical reasoning.

4. The students' attitude towards the use of active pedagogy in the classroom.

The findings to these issues are well elaborated in the ensuing pages of this chapter. A sample of Three-hundred and forty (340) students were selected from the final year class, comprising of one-hundred and seventy (170) students for the experimental groups which represent 50% and one-hundred and seventy (170) students for the control groups which also represented 50% of the sample.

4.1. Results of Research Question One: What teaching approaches are used by mathematic teachers in the Senior High Schools of the WMD?

To find out the teaching approaches used by mathematics teachers in the Senior High Schools in WMD, the researcher observed lessons taught by mathematics teachers in the selected schools where the research was conducted. Fifteen (15) mathematics teachers in total were observed during their lesson periods. That is, mathematics teachers were observed during their lesson periods and a check list of pedagogical practices was used to indicate the teaching activities that they used to engage their students. This data was then organized into a frequency distribution table containing each teaching approach and the number of mathematics teachers who practiced them. This organized data is shown in Table 4.1.

Table 4.1: Observed Teaching Approaches of Mathematics Teachers

Teaching Approach	**Frequency**	**Percentage (%)**
Traditional approach	14	93.30
Active pedagogy approach	1	6.70

The results from Table 4.1 indicates that, fourteen (14) out of fifteen teachers representing 93.3% of the teachers observed, used the conventional or traditional teaching method, one (1) teacher representing 6.7% of the teachers observed were found using active pedagogy. There were no other teaching approaches observed by the researcher.

4.2. Results of Research Question Two: What is the Level of Achievement of Senior High School Students in Logical Reasoning by the Teaching Approaches used by Mathematics Teachers in WMD?

To answer the above research question, the pre-test scores of the respondents were sorted and analyzed to establish a baseline for further statistical inference. The data was organized into a table as shown in Table 4.1.

Table 4.3: Descriptive Statistics of Student's Pre-test Scores

	N	Mean Score	Std. Deviation
Traditional teaching approach	170	7.99	2.227
Active pedagogy teaching approach	170	8.16	2.194
Total	**340**	**10.66**	**2.844**

Based on Table 4.2, senior high school students made different mean achievements by teaching approach. For the pre-test, the mean achievement made by students who were taught using the traditional teaching approach was (M=7.99) with standard deviation (SD= 2.227). Similarly, the mean achievement made by students who were taught using the active pedagogy teaching approach was (M=8.16) with standard deviation (SD= 2.194). This indicated that, before the intervention, students belonging to both groups (control and experimental) had mean achievement difference of 0.170. Now, there is the need to determine whether or not this difference in mean achievement is statistically significant. Table 4.3 gives the results of the analysis of variance of the mean achievement made by students in the pre-test.

Table 4.4: Analysis of Variance Students' Pre-Test Scores

		Sum of Squares	df	Mean Square	F	Sig.
Pre-test	Between Groups	2.647	1	2.647	.542	.462
	Within Groups	1651.365	338	4.886		
	Total	**1654.012**	**339**			

The analyses of variance gave *F(1,338)= .542* and *p-value = .462*. Since *p> .05*, it indicates that the mean achievement made by students in the pre-test was not statistically significant. That is to say that, before the intervention, students from the control groups as well as those from the experimental groups were on the same level of achievement in logical reasoning.

Determining Students' Achievement in Logical Reasoning by the use of Effect Size

An effect size identifies the strength of the conclusions about group differences or the relationships among variables in quantitative studies. It is a descriptive statistic that is not dependent on whether the relationship in the data represents the true population. The calculation of effect size is very important since it can be used to explain the variance between two or more variables or the differences among means for groups. It shows the practical significance of the results apart from inferences being applied to the population.

$$Effect\ size(\eta^2) = \frac{[Mean\ of\ experimental\ group] - [Mean\ of\ control\ group]}{Pooled\ standard\ deviation}$$

$$Effect\ size(\eta^2) = \frac{M_E - M_C}{\sqrt{\frac{(N_E - 1)SD_E{}^2 + (N_C - 1)SD_C{}^2}{N_E + N_C - 2}}}$$

Where M_E *and* M_C represent mean achievement of the experimental and control groups respectively. N_E *and* N_C correspond to the number respondents in the experimental and control groups respectively, and SD_E *and* SD_C are their respective standard deviations.

From Table 4.5, $N_E = 170$ *and* $N_C = 170$, $M_E = 8.16$ *and* $M_C = 7.99$ and finally, $SD_E = 2.194$ *and* $SD_C = 2.227$. hence the effect size is calculated as shown below.

$$Effect\ size(\eta^2) = \frac{8.16 - 7.99}{\sqrt{\frac{(170-1)\times 2.194^2 + (170-1)\times 2.227^2}{170 + 170 - 2}}}$$

$$= \frac{0.17}{\sqrt{\frac{3833.116885}{338}}} = \frac{0.17}{2.21} = 0.077$$

$$Effect\ size(\eta^2) = 0.077$$

According to Cohen (1969) an effect size less than 0.5 (i.e. $\eta^2 < 0.5$)is described as small and when the effect size is equal to 0.5 (i.e. $\eta^2 = 0.5$), it is described as medium and an effect size greater than 0.5 (i.e. $\eta^2 > 0.5$) is seen as large. Therefore, the effect size before the intervention was 0.077 (i.e. $\eta^2 < 0.5$) and that shows a very small effect. Hence, before the intervention, students from the control groups as well as those from the experimental groups were on the same level of achievement in logical reasoning.

Again, students' gain in achievement by teaching approach can be appreciated more when presented graphically. From Figure 4.1, the horizontal axis represents the question numbers on the logic achievement test, and the vertical axis represents the number of students who answered each question correctly. For each question, there are two (2) bars, the first bar represents number of students who answered that question correctly in the pre-test and the second bar represents number of students who answered correctly that question in the post-test.

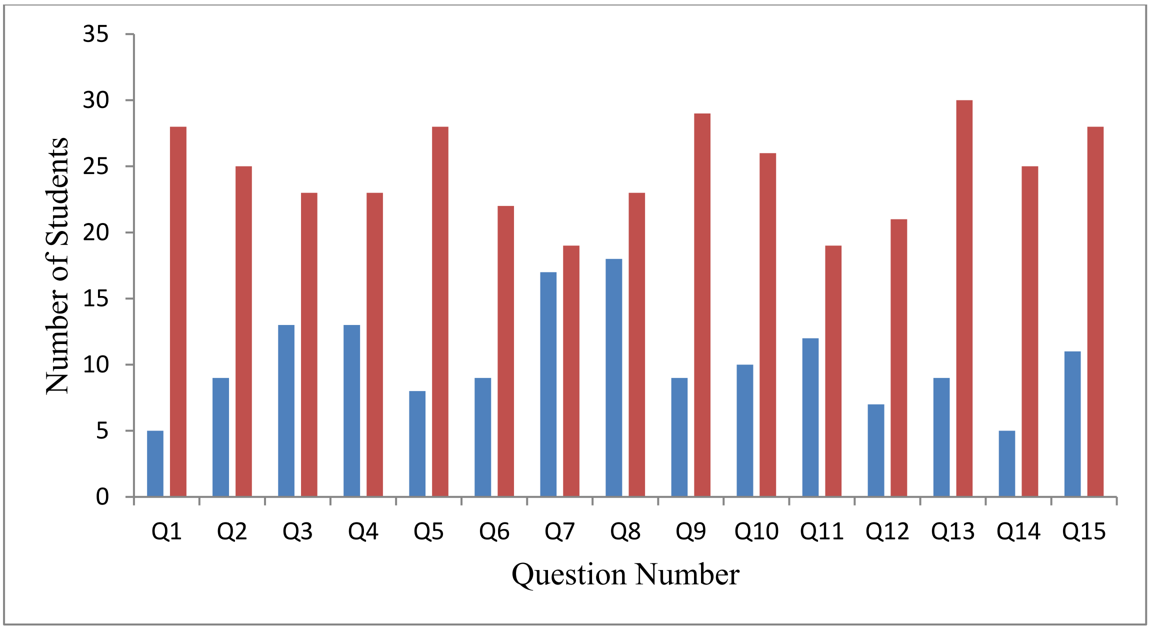

Figure 4.1: Pretest – Post-test Response Frequency Graph for Students who were taught by the Traditional Teaching Method

A total number of forty-five respondents were selected for this analysis. In order to determine level of achievement made by the students in the pre-test, it is expected that half or more of the students should be able to answer each question correctly. But if the first bars are observed critically, it appears that in almost all the questions, with the exception of questions 7 and 8, the bar graphs do not exceed a third of the total frequency, this indicate that the majority of the students achieved less in the pre-test. That is to say that about two thirds of the total students who responded to the pre-test from control group achieved less in logical reasoning. However, when the second bars are closely observed, it appears that with almost all the questions without exception, the bar graphs exceeded slightly above half of the total frequency, this indicates that the majority of the students achieved marginally higher in the post-test than the pre-test. Finally, the response frequency graph for pre-test – post-test of the students taught by the use of active pedagogy was analyzed and the result presented in Figure 4.2.

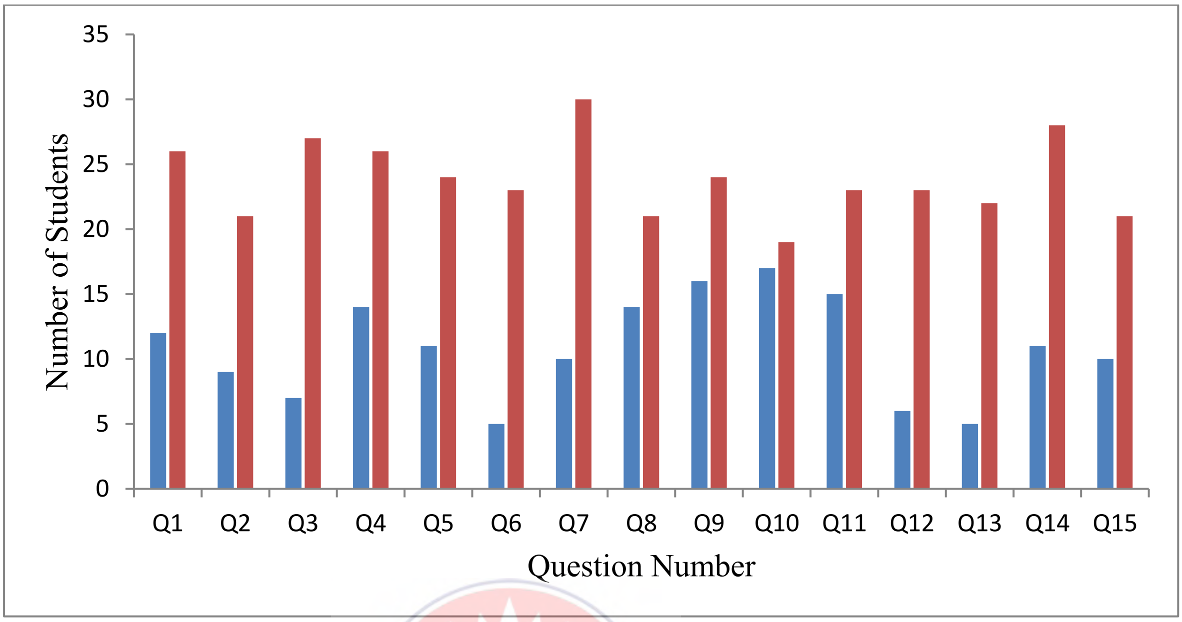

Figure 4.2: Pre-test–Post-test Response Frequency Graph for Students who were Taught using Active Pedagogy Method

Here, if the first bars are observed critically, it appears that in almost all the questions, with the exception of question 10, the bar graphs do not exceed a third of the total frequency, this indicates that the majority of the students achieved less in the pre-test. However, if the second bars are observed critically, it appears that almost in all the questions without exception, the bar graph exceeds slightly the second quartile of the total frequency, this indicates that the majority of the students achieved higher in the post-test than the pre-test by active pedagogy teaching method.

4.3. Results of Research Question Three: What is the effect of Active Pedagogy on Senior High School Students' Achievement in Logical Reasoning in the WMD?

To answer the above research question, the following hypothesis was formulated and tested using parametric test, specifically, the analysis of variance (ANOVA).

H_o: There is no significant difference in achievement between students taught using active pedagogy teaching approach and those taught using the traditional teaching approach.

Since parametric test is used, the data must satisfy the assumptions that underpin this test. The pre-test and post-test scores for the two teaching approaches were tested to ensure that these assumptions were not violated.

The Kolmogorov-Smirnov (K-S) test is generally used to check the normality of the data. Levene's test is used to examine whether the variances in the groups are equal. Both the K-S and Levene's tests assess the null hypothesis, assuming that the distribution of the population is normal, and variances between groups are equal. If the result of the K-S test is non-significant ($p>.05$), it suggests that the distribution of the data does not significantly deviate from normality; whereas if the result is significant ($p<.05$), the distribution of data deviates from normality. A deviation from normality suggests that the application of parametric tests is not tenable. Table 4.4 shows the Kolmogorov-Smirnov's test of normality results for both the pretest and post-test.

Table 4.5: Tests for Normality

Test scores	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	statistic	df	Sig.	statistic	df	Sig.
Pre-test	.175	338	.069	.950	338	.070
Post-test	.088	338	.057	.980	338	.063

The pretest scores gave a Kolmogoro-Smirnov statistic of .175 and significant value of .069 (p>.05), it also gave a Shapiro-Wilk statistic of .950 and significant value .070 (p>.05). These indicate that the assumption of normality was not violated for the pretest scores. Similarly, the post-test scores gave a Kolmogoro-Smirnov statistic of .088 and significant value of .057 (p>.05), it also showed a Shapiro-Wilk statistic of .980 and significant value .063 (p>.05) all of which suggests that the normality assumption was not breached.

The researcher also tested homogeneity of variance to ensure that this assumption was not violated. In a similar way to the indications produced by a K-S test, if the results of Levene's test are significant (p<.05), the variances are not significantly equal among groups; therefore, the assumption of homogeneity of variances has not been satisfied, and vice versa. The results of the K-S test and Levene's test for the given achievement assessments are presented only to justify the use of parametric or non-parametric tests Table 4.5 makes visible or noticeable the results of Levene's test of homogeneity of variance for both the pretest and post-test.

Table 4.6: Levene's Test for Homogeneity of Variance

	Levene Statistic	df1	df2	Sig.
Pre-test	.719	1	338	.397
Post-test	.359	1	338	.550

The pretest scores gave a significant value of .397 (p>.05), indicating that the assumption homogeneity of variance has not been violated for the pretest scores. The post-test scores also gave a significant value of .550 (p>.05) which suggests that the assumption of homogeneity of variance was not breached.

The K-S test showed that the scores of the groups at the pretest and post-test were normally distributed in that they were not statistically significantly deviant from a normal distribution, in the same way the Levene's test also indicated that the scores of the groups at the pretest and post-test were non-significant. For this reason, the researcher continued to run the ANOVA test whose result is displayed in Table 4.6. and Table 4.7 below.

Table 4.7: Descriptive Statistics of Student's Post test Scores

		N	Mean	Std. Deviation	Std. Error
Post-test	Traditional teaching approach	170	16.53	3.991	.306
	Active pedagogy teaching approach	170	18.18	3.843	.295
	Total	**340**	**17.36**	**3.999**	**.217**

Based on Table 4.6, senior high school students made different mean achievements by teaching approach for the post test. The mean achievement made by students who were taught using the traditional teaching approach was (M=16.53) with standard deviation (SD= 3.991). Similarly, the mean achievement made by students who were taught using the active pedagogy teaching approach was (M=18.18) with standard deviation (SD= 3.843). This indicated that, after the intervention, students belonging to the control and experimental groups had mean achievement difference of 1.65. Now, there is the need to determine whether or not this difference in mean achievement is statistically significant. Table 4.7 gives the results of the analysis of variance of the mean achievement made by students after the intervention.

Table 4.7: Analysis of Variance Results of students' Post-test Scores

		Sum of Squares	df	Mean Square	F	Sig.
Post-test	Between Groups	232.238	1	232.238	15.131	.000
	Within Groups	5187.700	338	15.348		
	Total	**5419.938**	**339**			

A one-way analysis of variance (ANOVA) was conducted to determine whether differences in the mean achievement of students who were taught by the teaching approaches (traditional and active pedagogy) after the intervention was statistically significant. The results from Table 4.6 gave *F(1,338)= 15.131* and *p-value = .000*. Since $p < .05$, it indicates that after the intervention, the mean achievement made by students in the post test was statistically significant. That is to say that, after the intervention, students from the control groups as well as those from the experimental groups were found not to be on the same level of achievement in logical reasoning. Hence a multiple comparison test was carried out on students' post test scores, to compare the mean achievements of all groups. The result of this test is shown in Table 4.8.

Table 4.8: Tukey's Multiple Comparisons Test

(I) Control and Experimental groups	(J) Control and Experimental groups	Mean Difference (I-J)	Std. Error	Sig.
Exp. Group 1	Control Group1	1.753*	.602	.023
	Control Group 2	1.306	.602	.185
	Exp. Group 2	-.247	.602	1.000
Exp. Group 2	Control Group1	2.000*	.602	.006
	Control Group 2	1.553	.602	.062
	Exp. Group 1	.247	.602	1.000

From the Tukey Post-Hoc multiple comparison test Table 4.8, it was observed that the mean difference in achievement between students from experimental group 1 and control group 1 was 1.533 with a significant value of .023 (p<.05). This indicated that, the mean difference in achievement between students from experimental group 1 and control group 1 was statistically significant. While the mean difference in achievement between students from experimental group 1 and control group 2 was not statistically significant since its significant value of .185 (p>.05). Similarly, the mean difference in achievement between students from experimental group 2 and control group 1 was 2.00 with a significant value of .006 (p<.05). This indicated that, the mean difference in achievement between students from experimental group 2 and control group 1 was statistically significant. While the mean difference in achievement between students from experimental group 2 and control group 2 was not statistically significant since its significant value of .062 (p>.05).

Determining students' Achievement in Logical Reasoning after the Intervention by the Use of Effect size

From Table 4.5, $N_E = 170 \; and \; N_C = 170$, $M_E = 18.18 \; and \; M_C = 16.53$ and finally, $SD_E = 3.843 \; and \; SD_C = 3.991$. hence the effect size is calculated as shown below.

$$Effect\ size(\eta^2) = \frac{18.18 - 16.53}{\sqrt{\frac{(170-1)\times 3.843^2 + (170-1)\times 3.991^2}{170 + 170 - 2}}}$$

$$= \frac{1.65}{\sqrt{\frac{5187.74737}{338}}} = \frac{1.65}{3.92} = 0.421$$

$$Effect\ size(\eta^2) = 0.421$$

The effect size after the intervention was 0.421 (i.e. $\eta^2 < 0.5$) and that shows small effect. The result from the ANOVA and the Multiple comparison test suggest that, there is statistically significant difference in achievement between students taught using active pedagogy teaching approach and those taught using the traditional teaching approach. But the effect of this difference is only 42%.

4.4Result of Research Question Four: What is Students' Attitude towards the Use of Active Pedagogy in the Classroom?

The active pedagogy strategies used in this study incorporated tenets which provide students with the opportunity to engage in listening, reading, writing, discussing, reflecting, and problem solving in the classroom. By use of an active approach to teaching and learning, the results on students' achievement were positive. A questionnaire response from thirty (30) students who were randomly selected from the experimental groups (students who were taught using active pedagogy teaching approach) suggested that, active pedagogy had other effects. The questionnaire analyses revealed that active pedagogy teaching approach improves students' scores or performance in logical reasoning, it also arouses the interest and curiosity of students to learn more. Table 4.9, represents students' response to the questionnaire. The first column on the table shows item's number in the questionnaire and the remaining columns show a five point Likert scale under which the frequency and percentage response of students for each point on the Likert scale is shown.

Table 4.9: Students' Perception on the Effect of Active Pedagogy Approach

No of items	Strongly agree		Agree		Neutral		Disagree		Strongly disagree	
	N	%	N	%	N	%	N	%	N	%
1	20	66.7	6	20.0	0	0.0	3	10.0	1	3.3
2	16	53.3	9	30.0	0	0.0	3	10.0	2	6.7
3	18	60.0	9	30.0	0	0.0	3	10.0	0	0.0
4	16	53.3	12	40.0	2	6.7	0	0.0	0	0.0
5	14	46.7	12	40.0	3	10.0	1	3.3	0	0.0
6	9	30.0	14	46.7	4	13.3	3	10.0	0	0.0
7	10	33.3	9	30.0	7	23.0	3	10.0	1	3.3
8	17	56.7	9	30.0	3	10.0	1	3.3	0	0.0
9	10	33.3	6	20.0	4	13.3	6	20.0	4	13.3
10	6	20.0	14	46.7	2	6.7	4	13.3	4	13.3
11	14	46.7	10	33.3	2	6.7	4	13.3	0	0.0
12	11	36.7	10	33.3	5	16.7	3	10.0	1	3.3
13	2	6.7	3	10.0	1	3.3	18	60.0	6	20.0
14	8	26.7	15	50.0	3	10.0	1	3.3	3	10.0
15	12	40.0	9	30.0	6	20.0	3	10.0	0	0.0

Item 1 of Table 4.9, sort students' opinion on their difficulties in understanding concepts in logical reasoning before the intervention, approximately 87% of the respondents agreed that they had many difficulties in understanding the concepts in logical reasoning before the intervention and the remaining 13% of the respondents said they had no difficulties in understanding concepts in logical reasoning before the intervention. But after the intervention, 80% of the students disagreed that they had difficulties in understanding concepts in logical reasoning and the rest of the 20% agreed that they still had difficulties in understanding concepts logical reasoning. This is shown in item 13 of table 4.9. In detail 83% of students found that active pedagogy helped them to better understand; 90% found that active pedagogy lesson was meaningful and 93.3% found it was well organized. On the other hand, 36.7% and 46.7% of students did not agree with the idea that active pedagogy encouraged interaction with other students and they effectively used the material provided in this topic respectively. This showed that there is individual difference among students when they are exposed to new learning approach, this may be due to the categories of students found in a class: fast learners, medium learners and slow learners. Moreover, 80.0% found that active pedagogy took more time than traditional teaching approach. Generally, 83.3% of students would like to use active pedagogy again. This indicated that students from the experimental groups showed positive attitude towards the use of active pedagogy.

Discussion of Results of Research Question One: What Teaching Approaches are Used by Mathematic Teachers in the Senior High Schools of the WMD?

This result supports the position of Fletcher (2008) when he argued that irrespective of the level at which mathematics is taught in Ghana, the role of the Ghanaian mathematics teacher has almost always been the same. The teacher explains, illustrates, demonstrates and in some cases gives notes on procedures and examples. Students are led deductively through small steps and closed questions to the principle being considered. At the worst, it becomes direct 'telling how' by the teacher. What is lacking in this approach is a sense of genuine enquiry, or any stimulus to curiosity of the student. Fletcher added that this method of teaching does not arouse students' interest and curiosity, sharpen students' thinking skills and prepare them for problem solving. The result is also in confirmation with the conclusion made by Charles-Ogan and Otikor (2016). They argue that to realize the objective of teaching mathematics, the readiness of the learner, teacher's proficiency and effective use of appropriate teaching strategies are important indices. The teaching of mathematics according to Ogunkunle (2007) has taken a stand point of talk and chalk at the secondary school level. The use of this method has become burdensome and of worry because, it does not establish the link between mathematics concepts learnt in the classroom and their applicability to real life situations, hence denying students of meaningful learning

(Ogunkunle & George, 2015; Sidhu, 2006). Jonah-Eteli (2010) observed that generally, teachers discuss worked examples, sometimes leading to formulae and then ask students to work exercises based on the examples or using the formulae. Jonah-Eteli concluded that, this method of teaching lead learners to memorize mathematical formulae, method and examples as presented by the teacher so much so that a little twist in a question already solved in class poses a great deal of treat to the students.

Discussion of Results of Research Question Two: What is the Level of Achievement of Senior High School Students in Logical Reasoning by the Teaching Approaches Used by Mathematics Teachers in WMD?

The results suggest that, students' achievement in logic reasoning is dependent on the teaching approach adopted in presenting the concepts there in. The results of students on the logic achievement test revealed that students' achievement was low for the pre-test but after the students have been taught using the two teaching approaches, students achieved higher than before. This means that, the teaching approach employed by the mathematics teachers in the SHS of the District helped improve students' achievement in logical reasoning.

Discussion of Results of Research Question Three: What is the Effect of Active Pedagogy on Senior High School Students' Achievement in Logical Reasoning in the WMD?

This conclusion is in harmony with Knypstra and Prins (2009) when they presented evidence suggesting that active learning is effective and enhances students' achievement in mathematics, they argue that the greatest effect of the use of active pedagogy approach are found in small classes where the number of students does not exceed fifty ($n \leq 50$). Christopher and Marek (2009), Ryan (2006) and Yoder and Hochevar (2005) also presented evidence that students' exam scores are higher when taught with an active learning approach than when taught with more traditional approaches. This can be observed in this study, in the case of the post-test scores for both the control and the experimental groups had improved in their test scores even though the scores of that of that students taught by active pedagogy was higher.

Contrary to the above researchers are those who found active pedagogy approach to have no effect on students' academic achievement (Pfaff & Weinberg, 2009) and worse to these is that active pedagogy approach hinders student performance (Weltman & Whiteside, 2010). This is not the case for this study, this study rather found mean difference between the control and experimental post-test scores which were further tested to be statistically significant.

Discussion of Result of Research Question Four: What is Students' Attitude towards the Use of Active Pedagogy in the Classroom?

From

Table 4.9 it is clear that majority of the respondents were of the view that active pedagogy teaching approach has positive effect on students' interest and curiosity to learn mathematics, retention of concepts and motivation. Exactly 87% of the students disagreed that learning by active pedagogy does not engage the interest of students and a small percentage 13% agree that learning by active pedagogy does not actually engage the interest of the students. Similarly, 80% of students who participated in answering the questionnaire agree and thinks that this teaching approach (active pedagogy) should be used by mathematics teachers in their classrooms. Likewise, students express the opinion that the active pedagogy teaching approach eliminates students' fear to expressing themselves in the classroom especially for the more timid students because it allowed them to interact with the teacher and their peers without exposing their weakness.

Finally, it is clear that active pedagogy has a positive impact on motivation, learning and social skill development of students, it is necessary that students understand and interiorize them. As such, active pedagogy strategies should be implemented from the basic education level to higher education as it will enhance the development and promotion of student's social skills and the promotion of academic success.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0. Overview

This chapter presents the summary of the study, conclusions based on the specific findings from the data analyzed and recommendations. The findings have been divided into four sections, each relating to the research question that underpinned the study. The first section deals with the examination of the teaching approaches used by mathematics teachers of the Senior High Schools in the WMD. The second section focuses on determining the achievement of Senior High School Students by teaching method in logical reasoning and the third section deals with the effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning in the WMD. The section ends with examining students' attitude towards the use of active pedagogy.

5.1. Summary of Key Findings

The study investigated effects of the use of Active Pedagogy on senior high school students' achievement in logical reasoning in the WMD of the North East Region of Ghana. The study involved Three hundred and forty (340) students selected from the four Public Senior High Schools from the district using purposeful and convenience sampling techniques. Test items, observation and questionnaire were used as instruments for data collection. These test items were design to test students understanding of specific concepts in logical reasoning. These concepts are quantifiers, conditional statements, syllogisms and relational reasoning. The data collected were analyzed using quantitative method. Descriptive statistics was used to determine the teaching approaches used by mathematics teachers in the Senior High

Schools and inferential statistics used to unveil the achievement of Senior High School Students by teaching method in logical reasoning and the effects of the use of Active Pedagogy on Senior High School students' achievement in logical reasoning in the WMD.

Following the analyses of research question one (1), it came to light that two teaching approaches were used by mathematics teachers in the Public Senior High Schools of the WMD. These were the conventional or traditional teaching approach and active pedagogy teaching approach. Even though these two teaching approaches were observed to be used, the majority of the mathematics teachers were found using the traditional teaching approach. This approach lacks the power to stimulate a sense of genuine enquiry, or curiosity of the student. Teaching by this approach does not help arouse student interest and curiosity, sharpen students' thinking skills and prepare students for problem solving. Hence prolong use of it could be detrimental to the students' achievement.

The study also unveiled from the analysis of research question two (2) that students made different mean achievement before and after the intervention. it appears that students' achievement in logical reasoning was equal before the intervention. That is to say that, before the intervention, students from the control groups as well as those from the experimental groups were on the same level of achievement in logical reasoning.

Again, an ANOVA was conducted to test the effect of active pedagogy on students' achievement in logical reasoning, the outcome established that after the intervention, the mean achievement made by students in the post test was statistically significant. That is to say that, after the intervention, students from the control groups as well as those from the experimental groups were found not to be on the same level of achievement in logical reasoning. Further test was carried out to find effect size this difference, here the Cohen-d test was used and the result indicated that teaching approach (active pedagogy) has small effect on students' achievement in logical reasoning.

Finally, after examining students' attitude towards the use of active pedagogy, it came to light that active pedagogy has a positive impact on students' attitude to leaning mathematic. As such, active pedagogy strategies should be implemented from the basic education level to higher education as it will enhance the development and promotion of student's social skills and the promotion of their academic success.

5.2. Conclusion

The study has shown that, majority of mathematics teachers in the Public Senior High Schools of the WMD use the traditional teaching approaches, but has been shown by many researchers to be less effective. it really does not help arouse student's interest and curiosity, sharpen students' thinking skills and prepare students for problem solving. Another major conclusion derived from this study is that the active pedagogy teaching approach was significantly better than the traditional teaching approaches in enhancing student's achievement in logical reasoning.

5.3. Recommendations

1. The Curriculum Research Development Division (CRDD) of the Ghana Education Service in collaboration with the related agencies in the Ministry of Education should organize in-service training for mathematics teachers in the district on the implementation of Active Pedagogy.

2. Teachers should re-examine their teaching methods to include more student-centered activities which will engage students and make them active participant teaching and learning process. This will invite a sense of excitement and fun for students to interact and learn.

5.4. Suggestion

1. Researchers who for the first time wish to investigate the effect of the use of Active Pedagogy on students' achievement in mathematics or other subject areas should have used the same pedagogical practice to teach these students at least for a term, so that the students become conversant with the practice.

2. Researchers who wish to investigate effect of the use of Active Pedagogy on students' achievement in other topics in mathematics or other subject areas should consider using smaller class size ($n \leq 30$) that is where the number of students does not exceed thirty. Such a class will be easier to manage and may produce a more accurate result.

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APPENDICES

APPENDIX A

LOGIC ACHIEVEMENT TEST (PRE-TEST)

Directions: Given below are questions (each is an argument). Each question has one or two premises followed by a conclusion. Assuming the premises are true, you are required to judge whether or not the conclusion is true or false and give a brief explanation to your judgment.

You have thirty (45) minutes to complete this test.

1. Nkrumah and Mills are great Ghanaians.
I condemn Nkrumah and Mills.
Hence I condemn great Ghanaians.

……………………………………………
……………………………………………

2. Either Kumah is a fool or a rascal.
Kumah is a rascal.
Hence kumah is not a fool.

……………………………………………
……………………………………………

3. Abraham is the father of Isaac.
Isaac is the father of Jacob.
Hence Jacob is the father of Abraham.

……………………………………………
……………………………………………

4. Stick A is longer than stick B.
Stick B is shorter than stick C.
Hence stick C is the shortest.

……………………………………………
……………………………………………

5. I am a woman.
Your mother was my mother's only child.
Hence I am your sister.

……………………………………………
……………………………………………

6. All oak trees have acorn.
This tree has acorn.
Hence it is an oak tree.

……………………………………………
……………………………………………

7. The book is on the table.
The table is on the floor.
Hence the book is on the floor.

………………………………………
………………………………………

8. Some men are wise.
Hence all men are wise.

………………………………………
………………………………………

9. Men are not men.
Hence men are women.

………………………………………
………………………………………

10. No large number is not zero.
Three is not a large number.
Hence three is zero.

………………………………………
………………………………………

11. If there is God, there is judgment.
There is no judgment.
Hence there is no God.

………………………………………
………………………………………

12. The learned are wise.
Mr. A is learned.
Hence Mr. A is wise.

………………………………………
………………………………………

13. All planets are round.
Pluto is round.
Hence Pluto is a planet.

………………………………………
………………………………………

14. Winter days are wet
This is a winter day.
Hence this day is wet.

………………………………………
………………………………………

15. If you smile then you are happy.
Yasmeen smiles.
Hence yasmeen is happy.

………………………………………
………………………………………

APPENDIX B

LOGIC ACHIEVEMENT TEST (POST-TEST)

Directions: given below are questions (each is an argument). Each question has one or two premises followed by a conclusion. Assuming the premises are true, you are required to judge whether or not the conclusion is valid or invalid and give a brief explanation to your judgment.

You have thirty (30) minutes to complete this test.

1. If you do good then you will enter paradise.
You did not do good.
Therefore, you will not enter paradise.
……………………………………
……………………………………

2. Every wise person is honest.
Atiku is not wise.
Therefore, Atiku is not honest.
……………………………………
……………………………………

3. Some animals are friendly.
All parrots are friendly.
Hence, some animals are parrots.
……………………………………
……………………………………

4. All prime numbers are divisible by 5.
Ten is a prime number.
Therefore, 10 is divisible by 5.
……………………………………
……………………………………

5. No large number is not zero.
Three is a large number.
Hence, three is not zero.
……………………………………
……………………………………

6. If there is God, there is judgment.
There is no God.
Hence, there is no judgment.
……………………………………
……………………………………

7. Only Ghanaians live here.
Otibo lives here.
Therefore, Otibo is a Ghanaian.
……………………………………
……………………………………

8. All cars are expensive.
Some machines are expensive.
Therefore, some cars are machines.
……………………………………
……………………………………

9. A is a part of B.
A has property C.
Therefore, B has property C.

……………………………………
……………………………………

10. Some poets are not teachers.
Hence, some teachers are not poets.

……………………………………
……………………………………

11. Ghana trades with Togo.
Togo trades with Libya.
Hence, Ghana trades with Libya.

……………………………………
……………………………………

12. Some students are obedient.
You are not a student.
Therefore, you are not obedient.

……………………………………
……………………………………

13. No reptiles have fur.
All snakes are reptiles.
Therefore, no snakes have fur.

……………………………………
……………………………………

14. Oxygen is gaseous.
Hydrogen is gaseous.
Hence, H2O is gaseous.

……………………………………
……………………………………

15. I touched you.
You touched him.
Hence, I touched him.

……………………………………
……………………………………

APPENDIX C

TOOL FOR OBSERVING MATHEMATICS TEACHERS' TEACHING APPROACHES

TEACHING STYLES	T1	T2
Teacher explains, illustrates, demonstrates, gives notes on procedure and solves examples for students to copy. Teacher task students to discuss a given problem, debate about it and above all justify their results. Collaborative work in student groups. Teacher uses questioning to get feedback from students and allow them to justify their results Peer-led, think, pair and share. Student's dominates classroom discussions by engaging in case study, take part in cooperative learning.		
Teaching Approach		

APPENDIX D

ACTIVE PEDAGOGY QUESTIONNAIRE

QUESTIONNAIRE FOR STUDENTS

You are requested to read the statement and answer each question bye (√) ticking against any one of the following five alternatives.

- ✓ Strongly Agree
- ✓ Agree
- ✓ Nutral
- ✓ Disagree
- ✓ Strongly Disagree

Further, I assure you that the response recorded by you will be kept secret and will in no case be used for any purpose other than research.

No.	Questionnaire statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	I had many difficulties in understanding logical reasoning before my discussion with you.					
2	The lesson allowed me to better understand logical reasoning.					
3	Group discussions during the lesson did contribute to my understanding of the topic.					
4	The lesson was well-organized					
5	The lesson was engaging.					
6	The lesson allowed me to apply my knowledge to solve problems.					

7	The lesson encouraged interaction with other students.					
8	I enjoy working in a group.					
9	I effectively used the material provided in this unit.					
10	During the lesson, I felt as though my opinions were valued.					
11	Active pedagogy takes up more time than the traditional approach.					
12	I have to take more responsibility for my learning in active pedagogy class.					
13	I have difficulties in understanding logical reasoning after my discussion with you.					
14	Teacher - Student discussion was emphasized, this eliminated students' fear to expressing themselves.					
15	I would like to learn mathematics using active pedagogy.					

THANK YOU.

APPENDIX E

LESSON PLAN THAT INSPIRE ACTIVE LEARNING

(Adapted from *Inspiring Active Learning* by Merrill Harmin with Melanie Toth)

Action Flow Lesson Sample 1: Think-Share-Learn

This lesson illustrates a high student involvement where questions are raised to stimulate student interest before the information is given.

Question, All Write *Whole class, 1-2 minutes*

- Pose a thought-provoking question to the whole class

  Examples: do you think human beings need logic in their daily activities and what is logical reasoning?

ANSWER

Logic is the backbone of critical thinking. It is extremely useful for uncovering error and establishing truth. According to Volker Halbach, Logic is the scientific study of valid arguments, it is compulsory for all rational beings because it allows us to test validity arguments and to distinguish correct reasoning from incorrect reasoning.

Why study logic?

The study of logic is essential because;

- It helps us to draw valid conclusions from given facts.
- It helps us to differentiate correct reasoning from incorrect/ fault reasoning etc.
- Guide the class to makes notes of the answers to the questions

- Do not be concerned if some students do not participate; rely on the flow of the action to eventually capture all students' attention.
- When three or four students finished writing announce, "Let's finish up your thought. I'll give you one more minute."
- Do not wait for the whole class to finish; keep the pace moving and upbeat.

Introduce students to some terminologies in logical reasoning

The following terminologies are very essential when studying logical reasoning.

- A **sentence** is a string of words making complete sense. E.g. let's go home, do not sleep here, is it midnight? Etc.
- A **statement** is a written or verbal sentence which is capable of being either true or false. E.g. I am not a student, you are not married, some girls are dangerous, and today is Monday etc. A statement is also called a claim or proposition.

There are two types of statements in logical reasoning, a positive (affirmation) and negative (denial) statements.

A positive (affirmation) statement is any sentence generally declared as true. E.g. all humans are imperfect,

A negative (denial) statement is any sentence generally declared as not true. E.g. the earth is not flat.

- Give more examples and let students share a few ideas.
- Do not let the discussion go too long
- Move on if you feel a slump.

<u>Sharing Pairs</u> *Small group, 5-6 minutes*

- Ask students to pair up with a partner, think, discuss and share ideas.

Concept test

Determine whether or not the sentences below are statements.

1. Look out!
2. How far is it to the next town? not a proposition.
3. $x + 2 = 2x$ not a proposition.
4. $x + 2 = 2x$ when $x = -2$ a proposition.
5. $X^2 + 3 = 7$
6. All cows are brown.
7. The Earth is further from the sun than Venus.
8. There is life on Mars.
9. $2 \times 2 = 5$.
10. Do you want to go to the movies?
11. Clean up your room.
12. $2x = 2 + x$.

This is a declarative sentence, but unless x is assigned a value or is otherwise prescribed, the sentence neither true nor false, hence, not a proposition.

When you see that two or three pairs are finished, wrap it up with an announcement such as "One more minute, please."

<u>Productive Discussion/Attentive Lecture</u> *Whole class, time as appropriate*

- Without waiting for all pairs to be ready (you want activity to catch students up and waiting is not an activity) ask, "Who will share something you or your partner talked about?"

- Say, "I have some thoughts about this." Continue your lecture only as long as the class remains attentive, move on.

Negation

This is use to deny the truth of a claim. It is denoted as (~), we can form the negation of a statement by adding the word "not" to the verb in that statement or removing the word not from the statement. Similarly, we can add the phrase "it is not the case that" at the beginning of the statement to form the negation of that statement.

Note: it is preferable to add the phrase "it is not the case that" at the beginning of the statement to form the negation of the statement. Examples:

- The cup is empty. The cup is not empty.

  It is not the case that the cup is empty.

- The time is not 2:00 am.

  it is not the case that the time is 2:00 am.

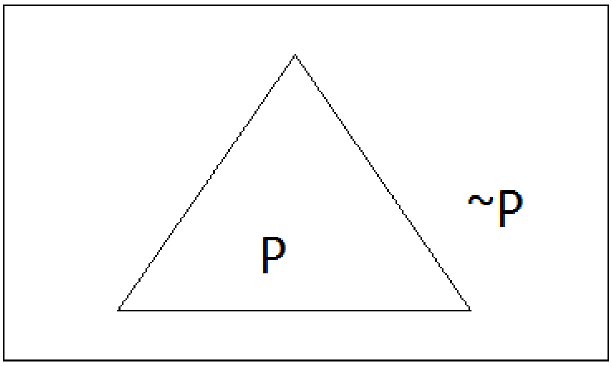
Using the Venn diagram to analyze negation of a statement

The negation of a statement is the space outside the set of that statement.

Symbolically, the negation of a statement p is denoted by $\sim p$.

Example: if given the statement,

p: Today is Sunday. ~*p*: Today is not Sunday.



Concept test

State the negation of the statements below and draw their respective Venn diagrams.

You are not mad.

It is not the case that you are not mad.

Short cuts are dangerous.

Short cuts are not dangerous.

It is not the case that short cuts are dangerous.

The time is 2:00 am.

<u>Question, All Write</u> *Whole class, 1-2 minutes*

- Pose new issue for students to respond to. Example what is an argument?
- This should be a question to advance student thinking.

ANSWER

An argument is a set (collection) of statements, one of which represents the conclusion and the rest of the statements represent the premises. Here argument normally means a conclusion supported by one or more reasons, all of which are statements. Here are some examples of arguments:

16. Failures are the steps towards success.

    Hence success comes after failures.

17. If I had worked hard, I should have passed.

    I have not worked hard.

    Hence I should not pass.

18. Eight and nine are even and odd. Seventeen is eight and nine.

    Hence seventeen is even and odd.

19. Either Kumah is a fool or a rascal. Kumah is a rascal.

    Hence kumah is not a fool.

- **Premises** are the statements that serve as reasons supporting the conclusion in an argument.
- **Conclusion** is a judgment reached after consideration. The conclusion has always had one of these words in it: therefore, consequently, thus, this means, so, it follows that, shows that, implies that, hence, in conclusion, for this reason, accordingly, as a result etc.

<u>Productive Discussion</u> *Whole class, time as appropriate*

- Pose a discussion opener such as, "Would someone please share reactions or questions about what I said or share any ideas you have?"

  Concept test

  Identify the premises and conclusion from the arguments below.

<u>Outcome Sentences</u> *Whole class, 1-2 minutes*

- Say, "Please think back over what we have done so far. Write two or three things you got from the lesson."

- Show the prompt list on the prompt list on the overhead to guide the responses.

I learned…

I was surprised…

I am beginning to wonder…

I rediscovered…

I feel…

I promise…

<u>Productive Discussion</u> *Whole class, time as appropriate*

Introduce students to the laws of logical reasoning and quantifiers

There are principles of logic and I would like to introduce you to the first three laws of thought. These laws are very important.

- The Law of Identity

- The Law of Non-Contradiction
- The Law of Excluded Middle.

The law of identity states that, A is A. An Apple is an Apple. In other words, something is what it is. You cannot say for example that men are not men. If something exists, it has a nature, and essence. For example, a book has a front and back cover with pages. A car has four wheels, seats, doors, windows, etc. A tree has branches, leaves, a trunk, and roots. These set of attributes must be consistent with the objects' own existence. It does not have a set of attributes that are inconsistent with itself. Because of this law we can easily see that a cat is not a dog, An Apple is not a mango. A tree is not a pole etc.

The law of non-contradiction tells us that A cannot be both A and not A at the same time and in the same sense. In other words, something (a statement) cannot be both true and false at the same time and in the same way. If I were to tell you that today is Friday and then later I told you that today is not Friday, you would be correct in saying there was a contradiction, since we know that both cannot be true. From this principle, we can conclude that truth is not self-contradictory. This is a very important concept. Let me repeat it. Truth is not self-contradictory.

The law of excluded middle says that a statement is either true or false. For example, my hair is brown. It is either true or false that my hair is brown. Another example: Esi is pregnant. She either is or is not pregnant - there is no middle position. The law of excluded middle is important because it helps us deal in absolutes.

Please review these three laws and become familiar with them. They are extremely important when developing critical thinking skills.

QUANTIFIERS

These are words that are used to specify the quantity of something. Words such as **"every, all, some, none, many and never"** to name a few are called quantifiers; they are used for making statements or propositions. We use these words in our everyday language.

Examples of Statements Containing Quantifies

Arguments normally have quantifiers in them, so in other to analyze such arguments we re-express the quantifiers in an equivalent form and then use the Venn diagram.

Ways of re-expressing Quantified Statements

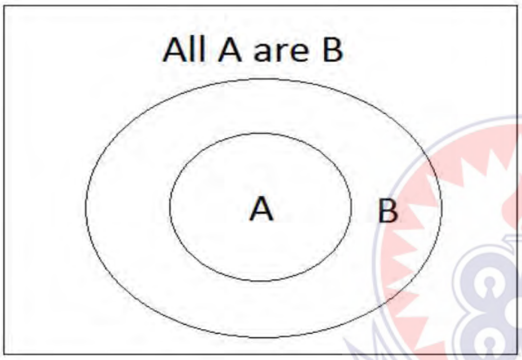
Statement	**Equivalent way to express it**	**Example**
All A are B	There are no A that are no B	All teachers are trained; There are no teachers that are not trained.
Some A are B	There is at least one A that is in B	Some people like ice-cream; At least one person likes ice cream.
No A are B	All A are not B	No car is running on the rail train; All the cars are not running on the rail train.
Some A are not B	Not all A are B	Some students do not pass the class; Not all of the students are passing the class.

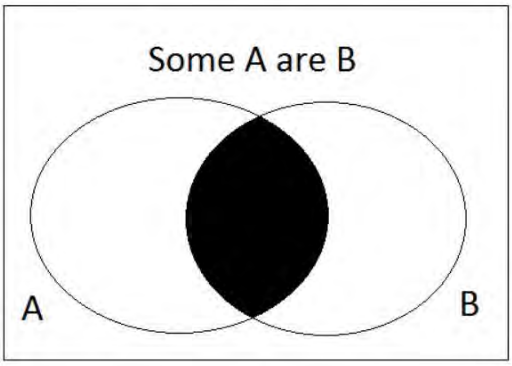
<u>**7. Whip Around, Pass Option**</u> *Whole class, 2-3 minutes*

- When a few students seem ready, say, "One more minute, please." You are alerting students that the lesson is about to move on.

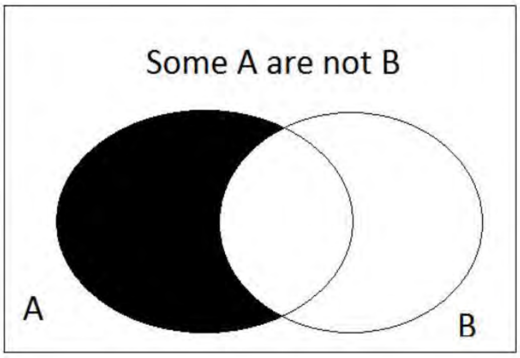
- Start with one student and ask him or her to read an outcome response. Rotate around the room with each student sharing.
- You might want to give the students the option to pass.
- If time permits, you can conclude with the following optional step.

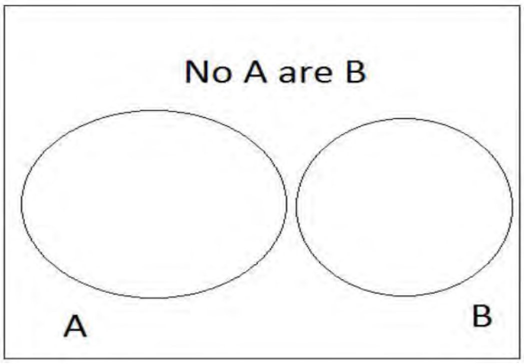
Analyzing statements involving quantifiers using Venn diagrams





CONCEPT TEST





Analyze the arguments below using the Venn diagrams.

1. If you do good then you will enter paradise.

   You did not do good.

   Therefore, you will not enter paradise.

2. Every wise person is honest.

   Atiku is not wise.

   Therefore, Atiku is not honest.

3. All parrots are friendly.

   Some animals are friendly.

   Hence, some animals are parrots.

4. All prime numbers are divisible by 5. Ten is a prime number.

   Therefore, 10 is divisible by 5.

   No large number is not zero.

5. Three is a large number.

   Hence, three is not zero.

   If there is God, there is judgment.

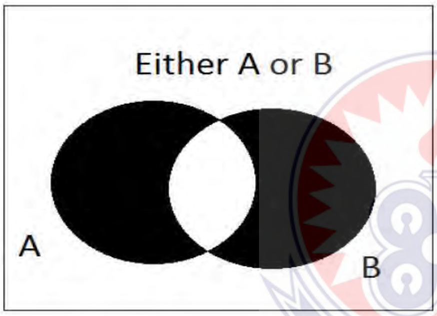
6. There is no God.

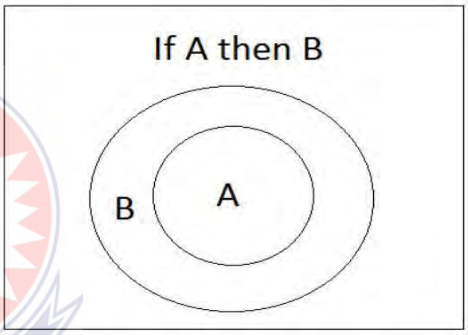
   Hence, there is no judgment.

<u>Sharing Pairs</u> *Small groups, time as appropriate*

- Students' partner up and share responses.
- Guide students to analyzing conditional statements

  Using the Venn diagram to analyze conditional statements





Concept Test

1. If there is God, there is judgment. There is no judgment.

   Hence there is no God.

2. If you smile then you are happy. Yasmeen does not smile.

   Hence yasmeen is happy.

3. If you do good then you will enter paradise.

   You did not do good.

Therefore, you will not enter paradise.

- End the class with a strong summary statement of what was accomplished today and what you will focus on in the next class.

EXERCISES

QUE. A

Consider the following statements:

P: If students work hard they will pass their examinations

Q: If students pass their examinations, then they do not sleep in class

(a) Draw a Venn diagram to represent the statements

(b) Deduce whether the following conclusions are valid or not

(i) Nana does not sleep in class so she is hard-working

(ii) Nii does not pass his examination so he sleeps in class

(iii) Naa works hard so she does not sleep in class.

QUE. B

Using Venn diagrams, indicate whether or not each of the following arguments is valid.

- Books borrowed for two weeks belong to Prof Alhassan. All Library books can be borrowed for two weeks. So all Library books belong to Prof Alhassan.

- A second degree equation in x and y has a term in xy. The equation of a circle is a second degree equation in x and y. Therefore the equation of a circle has a term in x and y.

- Thrice the number x is greater than 20. 20 is equal to five times x. Therefore thrice the number x is greater than five times the number x.
- Some numbers are multiples of 6. Some numbers are multiples of 11. Hence, some multiples of 6 are also multiples of 11.
- Some animals are friendly. All parrots are friendly. Hence, some animals are parrots.
- All students enjoy going to school. Some people in Damongo are students. Therefore some people in Damongo enjoy going to school.
- All squares have four lines of symmetry. Some rhombuses are squares. Therefore some rhombuses have four lines of symmetry.
- All prime numbers are divisible by 5. Ten is a prime number. Therefore 10 is divisible by 5.
- All diamonds are very expensive. Some cars are very expensive. Hence, some cars are diamonds.
- My brothers like playing soccer. All male Brazilians like playing soccer. Therefore my brothers are all male Brazilians.

QUE. C

Consider the following two statements:

a. Some students are hardworking.

b. Some hardworking students are not careless.

c. Draw a Venn diagram to illustrate the above statements.

d. State whether the following conclusions are valid or not valid from the statements

i. i. Jacob is careless Jacob is hardworking.

ii. ii. Zenzen is hardworking Zenzen is careless.

iii. iii. Owusu is not a student Owusu is not careless.

QUE. D

The following statements are true of a certain school.

X: There is **no** left-handed boy in the school team.

Y: **All** the good students of Mathematics are in the football team.

a. Draw a Venn diagram to illustrate the statements.

b. Using your Venn diagram, state whether or not each of the following is a valid deduction from.

i. i. Fosu is not a good student of Mathematics; therefore he is not in the football ii. team. (ii) Opare is left-handed so he is not a good student of Mathematics.

APPENDIX F

APPLICATION LETTERS FOR PERMISSION TO CARRY OUT RESEARCH

Yahaya M. Sherif-Deen,

Post Office Box 981,

Tamale.

March 14th, 2017

The Headmaster,

Walewale Senior High Technical School,

Post Office Box 11,

Walewale N/R.

Dear Sir,

APPLICATION FOR PERMISSION TO CARRY OUT ACADEMIC RESEARCH WORK IN YOUR INSTITUTION

I Yahaya M. Sherif-Deen, a final year Master of Philosophy in Mathematics Education student from the University of Education Winneba, wish to apply to your high office for permission to carry out my academic research work in your school on the topic 'investigating the effect of the use of active pedagogy on students' achievement in logical reasoning'.

This will take a maximum of 14 days to complete and I wish to start immediately.

The outcome of this research will serve as a resource for curriculum developers and teachers to help improve Senior High School Students' learning outcomes in logical reasoning and mathematics as a whole.

Please find attached an introductory letter from my institution for your consideration.

Thank you.

Yours faithfully,

Yahaya M. Sherif-Deen
0205500221/0548333338

Yahaya M. Sherif-Deen,

Post Office Box 981,

Tamale.

March 14th, 2017.

The principal,

Walewale Vocational/ technical institute,

Post Office Box 13,

Walewale N/R.

Dear Sir,

APPLICATION FOR PERMISSION TO CARRY OUT ACADEMIC RESEARCH WORK IN YOUR INSTITUTION.

I Yahaya M. Sherif-Deen, a final year Master of Philosophy in Mathematics Education student from the University of Education Winneba, wish to apply to your high office for permission to carry out my academic research work in your school on the topic 'investigating the effect of the use of active pedagogy on students' achievement in logical reasoning'.

This will take a maximum of 14 days to complete and I wish to start immediately.

The outcome of this research will serve as a resource for curriculum developers and teachers to help improve Senior High School Students' learning outcomes in logical reasoning and mathematics as a whole.

Please find attached an introductory letter from my institution for your consideration.

Thank you

Yours faithfully,

Yahaya M. Sherif-Deen
0205500221/0548333338

Yahaya M. Sherif-Deen,

Post Office Box 981,

Tamale.

March 14th, 2017.

The Headmaster,

Marakaz Islamic Senior High School,

Post Office Box 15,

Walewale N/R.

Dear Sir,

APPLICATION FOR PERMISSION TO CARRY OUT ACADEMIC RESEARCH WORK IN YOUR INSTITUTION

I Yahaya M. Sherif-Deen, a final year Master of Philosophy in Mathematics Education student from the University of Education Winneba, wish to apply to your high office for permission to carry out my academic research work in your school on the topic 'investigating the effect of the use of active pedagogy on students' achievement in logical reasoning'.

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Please find attached an introductory letter from my institution for your consideration.

Thank you.

Yours faithfully,

Yahaya M. Sherif-Deen
0205500221/0548333338

APPENDIX G

INTRODUCTORY LETTER FROM UNIVERSITY OF EDUCATION WINNEBA

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF MATHEMATICS EDUCATION

P. O. Box 25, Winneba, Ghana. Tel: 233- 0432-220989, E-mail: maths @uew.edu.gh

August 15, 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

LETTER OF INTRODUCTION

The bearer **YAHAYA M. SHERIF-DEEN** with index number **8150110015** is an M.Phil student of the Department of Mathematics Education, University of Education, Winneba. His year of entry was 2015/2016 academic year and he is expected to complete in 2017.

We shall be very pleased if you could offer him the necessary assistance.

Thank you in anticipation.

Yours faithfully,

UNIVERSITY OF EDUCATION, WINNEBA
SIGN
DATE
DEPARTMENT OF MATHEMATICS EDUCATION

PROF. D. K. MEREKU
Head of Department