UNIVERSITY OF EDUCATION, WINNEBA

USING PROBLEM-BASED LEARNING APPROACH TO IMPROVE THE PERFORMANCE OF SCIENCE STUDENTS IN MOLE CONCEPT: A CASE STUDY AT TECHIMAN SENIOR HIGH SCHOOL

FELIX KYEREMEH OWUSU

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DECLARATION

I, Felix Kyeremeh Owusu, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:…………………………….

DATE:…………………………………….

SUPERVISOR’S DECLARATION

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

SUPERVISOR‟S NAME: Dr. E. K. Oppong

SIGNATURE :…………………………

DATE:……………………..…………

DEDICATION

I dedicate this work to my family.

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My special thanks go to the Almighty God for the abundant grace bestowed upon me throughout my entire academic endeavour and who in due time makes all things not only possible but also beautiful.

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ABSTRACT

The purpose of the study was to determine the effectiveness of problem-based learning (PBL) approach to mole concept among students of Techiman Senior High School**.** The study was quasi-experimental research and nonrandomized control group pre-test – post-test design. The total population considered for the study was 243 second year students of Techiman Senior High School. The sample size was 74 second year students offering the General Science Programme. The selection procedure was nonrandomized. Intact or already existing classrooms were used for the study. The control group consisted of 37 second year students and the experimental group was equally 37 second year students as this arrangement was the prevailing situation in the two intact classes at the time the study was conducted. In the experimental group, the Problem-Based Learning (PBL) approach was used while the Traditional Lecture-Based (TLB) method was used in the control group. The instrument used in the study was the Mole Concept Achievement Test (MCAT) which took the form of pre-test and post-test. The reliability coefficients were found to be 0.736 and 0.751 for the pre-test and post-test respectively. Data were analysed using t-test and bar charts. The results of the study revealed that the PBL resulted in significantly higher students‟ achievement in mole concept than the TLB.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter consists of the background to the study, statement of the problem, problem diagnosis and causes of the problem. It further focuses on the purpose and objectives of the study, questions that guide the study, significance of the study, limitation, delimitation and definition of terms.

1.1 Background to the Study

The researcher was assigned to teach chemistry in Form Two science classes. The researcher was to teach a lesson on solubility. As the researcher reviewed the relevant previous knowledge of 2 Science 1 (2S1) students on mole concept, through questioning and answering, it was observed that they had difficulty in mole concept. The problem was the same when the researcher taught the 2 Science 2 (2S2) and 2 Science 3 (2S3) students. The researcher requested for their exercise books to have a look at the exercises students did last term on mole concept. It was observed that student"s performances were very poor.

This poor performance of the students in their previous knowledge on mole concept prompted the researcher to organise a pre-test for 2 Science 1 (2S1) and 2 Science 2 (2S2) students. This was to find out whether the problem still existed and if it did, where the students had difficulties.

The results revealed that out of seventy four (74) students, ten and nine students in the 2 Science 1 and 2 Science 2 respectively obtained total scores within the range of 1-5. Twelve students in the 2 Science 1 and twelve students in the 2 Science 2 had their total scores within the range of 6-10. Also nine students in the 2 Science 1 and eleven students in the 2 Science 2 obtained total scores within the range of 11-15. Within the range of 16-20 scores, five and four students in the 2 Science 1and 2 Science 2 respectively got their scores in that range. Only one student in the 2 Science 1 and one student in the 2 Science 2 obtained a total score within a range of 21-30. The results showed that the majority of the students (seventy-four) that is thirty in the 2 Science 1 and twenty-eight in the 2 Science 2, out of a total of seventy-four students selected for the study obtained scores starting from one to fifteen. Just few students (sixteen), seven in the 2 Science 1 and nine in the 2 Science 2 out of a total of seventy four (74) students had scores above fifteen. This observation motivated the researcher for this study.

1.2 Statement of the Problem

The problem addressed by this study was that second year students offering science programme in Tachiman Senior High School have difficulties in understanding the mole concept.

1.3 Purpose of the Study

This action research was to find out the effectiveness of problem-based learning approach to mole concept among science students of Techiman Senior High School (TSHS). The study also sought to ascertain the influence of gender on students" achievement in mole concept.

1.4 Research Objectives

The objectives of the study were to:

1) Determine the difference in achievement of the students in the mole concept in the experimental and control groups before the treatments using the PBL and the TLB approaches respectively.

2) Examine the difference in achievement of the students in the mole concept in the experimental and control groups after the treatments using the PBL and the TLB approaches respectively.

3) Evaluate whether gender influences the students‟ achievement after exposure to PBL.

1.5 Research Questions

The study was intended to answer the following questions;

1) What is the difference in achievement of the students in the mole concept in the experimental and control groups before the treatments using PBL and TLB approaches respectively?
2) What were the differences in achievement of the students in the mole concept in the experimental and control groups after the treatments using the PBL and the TLB approaches respectively?
3) What will be the gender influence on students‟ achievement in the mole concept after exposure to problem-based learning approach?

1.6 Research Hypotheses

The following hypotheses were tested at 0.05 level of significant difference.

Ho1: There is no significant difference in the pre-test achievement mean scores of the students in the mole concept in the experimental and control groups before the treatments using the PBL and the TLB approaches respectively.

Ho2: There is no significant difference in the pre-test and post-test achievement mean scores of students‟ taught the mole concept using problem-based learning strategy and those taught using lecture method

. **Ho3:** There is no significant difference between the mean scores of male and female students" on the post-test scores in the mole concept after exposure to problem-based learning strategy.

1.7 Significance of the Study

It is anticipated that this study will result in better performance by 2 Science 1 students (2S1) of Techiman Senior High School (TSHS) regarding the mole concept. In addition, the outcome, suggestions and recommendations of this research will be made available to future teachers who will handle Chemistry at Techiman Senior High School (TSHTS) and other school who would have similar problem. Finally, the study will serve as a resource for further research work.

1.8 Delimitation to the Study

The study was delimited to 2 Science 1 (2S1) students for the study because they had much difficulty in mole concept as compared to the other classes. Again, the researcher taught chemistry in that class and the class size was small. Also, problem-based learning approach was used as the main teaching and learning strategy for the study because the researcher taught that was the appropriate teaching and learning strategy for the study. The main instruments used for the study were delimited to pre-achievement test and post-achievement test because the researcher taught they were effective ways of securing information from students and were ideal methods that help to measure students" performance.

1.9 Limitation to the Study

The research should have involved all the second year science students at the Techiman Senior High School which would have given a fairer view of the problem but due to time constrains, limited logistics and funds, it was limited to 2 Science 1 and 2 Science 2 students. Producing a study of this nature requires a lot of inputs which include collection of information, willing attitude and co-operation of respondents and teachers. Also for the fact that thee researcher have to combine the study with teaching, all within one academic year, makes the research to be limited to only 2 Science 1 and 2 Science 2 students.

1.10 Definition of Terms and Abbreviations

PBL………..Problem-Based Learning

TLB………Tradition Lecture-Based

MCAT……..Mole Concept Achievement Test

SHS.............Senior High School

WAEC..........West African Examination Council

WASSCE ....West African Secondary School Certificate Examination

TSHS ……..Techiman Senior High School

MOE................Ministry of Education

GES..................Ghana Education Service

2S1…………Form Two Science 1

2S2…………Form Two Science 2

2S3…………...Form Two Science 3

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

In this chapter, related literature to this study has been reviewed under mole concept, problem-based learning approach, lecture method, Gender, science learning and pre-test and post-test.

2.1 Mole Concept

The level of science education is one of the measures of growth of any nation (Nwachukwu, 2012). Science and technology are said to be the engines of growth and development of every nation. Medicine, engineering, telecommunication, agriculture and pharmacy which are significant indicators for national development all have their roots in the study of science, yet students have difficulties in studying science due to poor foundation and methods of teaching. Many students prefer to study courses in humanities than in sciences. There are normally few students studying science from the senior high school level to the tertiary level. Unfortunately, the numbers keep dropping from the senior high school to the tertiary level.

Chemistry is a very important subject, although students have difficulties studying it. According to Sirhan (2007), chemistry is often regarded as a difficult subject, which sometimes repels learners from continuing with its studies. There are a number of difficult concepts in chemistry such as balancing of chemical equations, redox reactions, nomenclature of hydrocarbons, mole concept and others that pose challenges to students" progress as they study the subject. The role of chemistry as a component of pure science to national development cannot be overemphasized. The knowledge of chemistry is greatly needed in all chemical industries in both developed and developing countries, nonetheless, many students continue to drop the subject as they progress with their studies or continue to have difficulties in understanding its concepts as they study it.

Regarding the difficult concepts in chemistry, the mole concept in particular is still a difficult area in chemistry for students in the colleges of education in Ghana. Students who do not fully understand the mole concept experience difficulties in understanding subsequent topics such as stoichiometry, chemical equilibrium, acids and bases (Üce, 2009). In science, most of the concepts are interlinked and built on one another. To study one concept effectively, the foundation of another concept would have been laid for that to be possible. If a student fails to understand certain basic or fundamental concepts in a given subject area in science, he/she will encounter difficulties in understanding subsequent concepts in the same subject area. For instance, a close examination of the definition of a mole of a substance creates problems for students. Brown, (2016) define a mole as "the amount of matter that contains as many objects (atoms, molecules or whatever objects we are considering) as the number of atoms in exactly 12 g of isotopically pure 12C" (p. 89). This very definition of the mole as a concept is difficult for many students to understand. The terms used in the definition create confusion for some students, thus making it difficult for them to fully comprehend the mole concept.

According to Dahsah and Coll (2007), the term carbon-12 atoms, causes some confusion among students owing to the fact that the numerical value (12) of the mass of the carbon atoms looks identical to the value of its molar mass. Another scenario of the mole that confuses students is that this very mole is termed as a concept because its definition talks about the amount of matter; it is also referred to as a unit of measurement because in calculation there can be an expression like „0.50 mole" and finally it is expressed as a number such that one mole is equivalent to the Avogadro"s number (6.02 x 10^{23}). Students" low achievement in the mole concept has a bearing on the confusion they face with the concept. The mole concept is an area that very few students like and succeed at, and which most students hate and struggle with because they find Stoichiometric calculations difficult (Polancos, 2009). This support a study by Docktor and Mestre (2014), which contends that students have acute difficulties in dealing with the abstract concepts required of them to perform stoichiometric calculations using the mole concept.

Stoichiometric calculations are also needed to evaluate the results of quantitative analyses like titrations. Chemical formulae can be calculated if it is known how much of each element is present in a compound. For these reasons stoichiometry has become an important topic in curricula and chemistry textbooks, and many investigations have been carried out to understand students´ problems in this field. Those published papers on stoichiometric problem solving that have been reviewed are Griffiths (1994), Gabel and Bunce (1994) as well as Furio et al. (2002).

Stoichiometric calculation belongs to the less attractive and more difficult areas in high school chemistry. Matriculation results in Israel have shown that achievement on mole concept questions was lower than the average achievement in the examination as a whole (Novick & Menis, 1976). Gable and Sherwood (1984) administered two tests to senior high school students. One problem set consisted of mole concept tasks, the other of analogue tasks. The analogue tasks were about oranges and other market produce which replaced chemical terms like sodium hydroxide, and concepts such as dozens instead of moles. Many students who successfully solved the analogue tasks were unable to solve the mole concept tasks. It seemed that the difficulties students had in solving the mole concept tasks were not due to the arithmetic needed but to the lack of understanding chemical terms including the mole. Schmidt (1994) studied senior high school students´ strategies for solving stoichiometry problems. He also proposed some teaching ideas to introduce stoichiometry (Schmidt, 1997). Dori and Hameri (2003) developed a learning programme for stoichiometry containing problems of varying difficulty. They also developed and validated an analysis system to predict the rate of students´ success in solving mole-related problems (Dori & Hameri, 2003).

The original Nuffield curriculum introduced stoichiometric calculations already in junior high schools. The quantitative aspect in chemical investigation is of fundamental importance. It must be present from the beginning. In Sweden, stoichiometry is introduced at senior high school level (Schmidt & Jignéus 2003). Swedish textbooks present a variety of problems in stoichiometry. They differ in what is given and what is required: mass, gas volume, amount of substance, molar mass, percent composition, volume of solution, molar concentration, and mass concentration. This situation has put researchers trying to find out teaching interventions that can improve students‟ achievement in the mole concept.

2.2 Problem-based Learning Approach

For sometime now, the commonest approach to teaching science including the mole concept has been the traditional lecture-based (TLB) method. Nonetheless, many students still have difficulties understanding the mole concept over the years. The question is whether the teaching method used by a teacher has any reflection on students‟ understanding of the subject taught. If the answer is yes, then the choice of a teaching method is very fundamental to assisting students" understanding of subjects taught in the classroom. Studies revealed that the teaching method employed by a teacher reflects on students" understanding of the subject (Sung & Hwang, 2013). Other researchers are also of the view that the teaching method adopted by the teacher in order to promote learning is of topmost importance to enhancing the academic performance of learners (Yusuf, & Afolabi, 2010). According to Njoku (2004), prominent among the contributing factors to students" persistent poor performance or under achievement in Chemistry include ineffective teaching methods or approaches used by science teachers to teach the subject.

Teaching difficult concepts like the mole concept calls for a teaching strategy or approach that is learner-centred and innovative enough to facilitate learners" interest. . According to Fatoke and Olaoluwa (2014), the traditional lecture method of teaching chemistry proved less effective than the problem-based method. One of the reasons for the better achievement in the mole concept using the PBL over the TLB confirmed a study by Raimi and Adeoye (2004), which contends that the superiority of problem based learning strategy over the traditional method could be attributed to the logical and sequential manner with which instructions are presented in problem based technique and practical skills teaching. Hirca (2011) contended that in traditional science lessons, teachers come to teach and students mimic their acts without understanding whatever is taught. This situation leaves many students with no alternative to learning than rote learning where concepts are simply memorized without understanding.

According to Hung (2009), problem-based learning (PBL) appeared to be the most innovative instructional method conceived and implemented in education with the aim of enhancing students" application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills. Problem solving strategies are learner-centred and are capable of making remarkable impact on instructional practices (Ogunyemi, 2010). Problem-based learning is a teaching method characterized by the use of problems or questions as a contest for students to discuss in a small group to learn problem solving skills and acquire knowledge about the content of concepts whilst the teacher serves as a facilitator. According to Dannawi (2013), students taught using the problem solving approach perform significantly better than those taught using the lecture method approach. A study conducted by Shehu (2015) on the effect of problem-based instructional strategies on students" learning outcomes in Senior Secondary School chemistry, revealing that students taught using problem-solving perform significantly better than those taught through lecture method in improving students" achievement in the mole concept. Within the same group (experimental group), the post test results were comparatively better than the pre-test results attesting to the effectiveness of the PBL in yielding better achievement among students in the mole concept. On the contrary, the students taught with the TLB showed lower achievement in the mole concept compared to those taught with PBL. No wonder study conducted by West (1992), showed that problem- based is a prominent feature in the learning of science and its neglect could have negative effect on students' learning outcome in the sciences.

It concentrates actively on generating, adapting and using knowledge to solve problems other than passively acquiring it and making no use of it. Problem-based learning is a total approach of education and involves a constructivist approach to learning (Musaa, Shafieb & Roslea, 2015). According to Savery (2006), PBL is an instructional approach that has been used successfully for over 30 years and continues to gain acceptance in multiple disciplines. The theoretical approach to this study was the constructivist theory. In the constructivist classroom, the teachers‟ role is to organize situations which will give way to the learners to hypothesize, predict, manipulate objects, pose questions, research, investigate and invent meanings relevant to what they are learning (Kibos, Wachanga & Changeiywo, 2015). A constructivist classroom is student centred that places emphasis on student learning rather than the teacher teaching. . These agree with the study of Akar (2005), which posited that the constructivist approach to teaching enables students to perform better in chemistry achievement test than the traditional lecture method. As a learner-centred method that challenges the learner to take a progressively increasing responsibility for his or her own learning, PBL is therefore consistent with the constructivist theory (Coombs & Elden, 2004). This agrees with the study of Hung (2009), which asserted that problem-based learning (PBL) appears to be the most innovative instructional method conceived and implemented in education with the aim of enhancing students‟ application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills. In PBL, students work in groups, have the opportunity to solve several questions and direct their own learning as opposed to TLB where students are simply given lectures with no room for working in groups as well as direct their own learning

There was similarity between PLB approach and the study of Burke (2011) on advantages of working in groups, emphasising that groups stimulate creativity, help people remember group discussions better, foster learning and comprehension and decisions that students help make yield greater satisfaction.

2.3 The Lecture Method

The lecture is one of the oldest and, maybe still, the most widely used teaching method in tertiary educational institutions. It has been a primary component in the teaching and learning programmes of Universities since the very early days of university education (Biggs , 2011). Given the increasing funding pressures facing higher education worldwide, the lecture will more than likely continue to be used extensively in higher education for many years to come (Bates & Poole 2003). Originally, lecturing was the major channel through which knowledge stored in books was transmitted to a large group of students. The word lecture comes from the Latin word „legere which translate „to read." A lecture is defined as one person speaking, more or less continuously, to a group of people on a particular subject or theme. For the university administrator, a lecture is "a slot in the timetable where students are taught in a designated space, a lecture theatre, in a group which size can vary from 20 to 800 and more, and where one lecturer has the primary responsibility for „delivering content" (Edwards, Smith & Webb, 2012).

Lecture is a teaching method where an instructor is the central focus of information transfer. Typically, an instructor will stand before a class and present information for the students to learn. Sometimes, they will write on a board or use an overhead projector to provide visuals for students. Students are expected to take notes while listening to the lecture. Usually, very little exchange occurs between the instructor and the students during a lecture. Short and Martin (2011) described this didactic method as education through the transmission of information and suggests that this theory of learning assumes that students are passive recipients of knowledge transmitted by the lecturer. The lecture method bases itself upon the transmissive teaching model-that is knowledge is an object that can be transferred from the teacher to the learner.

Practically it implies a lecturer holding a lecture for a group of people. The strength is that it is possible to educate large number of people at once, thereby lowering costs. A limitation is that it yields less deep knowledge compared to other teaching methods such as case-based learning (Marmah, 2014).

Many educators believe that the traditional lecture approach to teaching is ineffective compared to active learning methods (Covill, 2011). Methods that promote active learning by students are based on the constructivist view that, for meaningful learning to occur, students must actively engage with the content to be learned through such activities as discussion, hands-on activities, and problem solving. According to proponents of the use of active learning methods, one main weakness of the lecture method is that it allows students to be passive recipients of information that has been "predigested" by the professor (Wood, 2013). Thus, students become dependent on the professor to tell them what they need to know and can avoid taking responsibility for their own learning (Covill, 2011). Further, students accustomed to being passive have a "low tolerance for challenge"(Hansen & Stephens, 2000). Finally, according to active learning activists, learning as a result of lectures is relatively superficial and transient (Moust, Van Berkel, & Schmidt, 2005).Whereas Marmah (2014) was of the view that lecture is largely a one-way process. There is not much interaction between the students and the teacher. It ignores individual differences; students are not attentive 40% of the time in class. Attention is high for the first 15minute then, attention levels decline rapidly until the final 10 minutes of class. Other research indicates that the lecture method is superior (Baeten, Dochy, & Struyven 2013).

Marmah (2014) was of the view that in many developing countries lecturing is the dominant and traditional method of instruction. The reasons for their popularity are not farfetched. Lecture method is quite economically and it is possible to handle a large number of students at a time and no laboratory, equipment, aids, and materials are required (Ojonubah, 2016). They are easily changed and up-dated and are efficient in covering materials quickly. Students‟ perception about the lecture method Previous research is mixed regarding students perceptions of the traditional lecture method as compared to teaching methods that require students to learn actively (Covill, 2011). On the one hand, many students report a preference for the lecture approach. For example, in one study, students in introductory economics classes preferred the lecture method compared to active learning and believed they learned more through lectures.

Leeds, Stull, & Westbrook, (1998). Additionally,on student evaluations, these students negatively evaluated teachers who required more work, as with active methods, and positively evaluated lecture-style teachers.

Researchers have found that students prefer the lecture approach for many of the reasons that education experts believe it to be weak: it "enables them to listen passively," "organizes the subject matter for them," and "prepares them well for tests" (McKeachie, 1997). Research conducted by Covill, (2011), noted that students who are faced with a teacher's demands that they be active and take responsibility for their learning "may become sullen or hostile:" they complain "that they are paying tuition to be taught, not to teach themselves". Baeten, Struyven, Dochy (2013) found students' evaluations of the lecture method to be mostly positive. A study by Carpenter (2006) suggested that students do not favour active learning methods because of the in-class time taken by the activities, fear of not covering all of the material in the course, and anxiety about changing from traditional classroom expectations to the active structure. Marmah (2014) examined students‟ perceptions across six teaching methods: lecture/discussion, lab work, in-class exercises, guest speakers, applied projects, and oral presentations. Students most preferred the lecture / discussion method. A study conducted by Marmah (2014) provided evidence that students place greater emphasis on lecture.

Most of the students rated lecture method as the best teaching method. Reasons given by the students included; teacher provides all knowledge related to the topic, it is a time saving method and students listen to the lecture attentively and take notes. On gender specific, the literature generally agrees that female instructors and students tend to use and prefer teaching techniques that are more interactive, such as class discussions, small-group discussions, and group projects. Such approaches are consistent with organization and other elements of feminist pedagogy. Men are more likely to use less personal approaches such as lecture and in-class computer applications. A study by Perrin and Laing (2014) on students" behaviour in relation to lectures as an effective method of instruction, found a noticeable difference between students attitude and behavior indicating a preference for discussions to lectures, however, when given the opportunity actually preferred the lecture to the discussion. Struyven, Dochy and Janssens (2005) emphasized perception as the reason for such behaviour. In a structured learning situation the university students prefer the "old school" approach of an engaging lecture over the use of the latest technological bells and whistles in the classroom. Geiger and Ogilby (2000) found that students who were taught, introductory financial accounting in a mass-lecture format performed more favourably than students who were taught exclusively in small classes. Nolan (1974) found that students preferred lectures as they felt compelled to take notes. Marmah (2014) were of the view that students whose performance is below average may be used to passive learning and may be comfortable with it for which reason;

they may prefer the lecture method to other teaching methods that would involve active participation of the learner.

In the same vein Jarvis, Holford and Griffin (2003) indicated that, some teachers prefer the lecture method since it gives them control over the class thus covering up for their knowledge. Despite the fact that most faculty and students do have preference for the lecture method, many educators believe that the traditional lecture approach to teaching is ineffective compared to active learning methods (Marmah, 2014). They were of the view that for meaningful learning to occur, students must actively engage with the to- be-learned subject-matter through such activities as discussion, hands-on activities, and problem solving. Cognitive theory has suggested that only active processing of information, and not just passive reception of that information, leads to learning. Lake (2001) gave further evidence indicating that very little learning occurs in lectures when they showed a weak correlation between lecture attendance and course grades in medical school courses. According to proponents of the use of active learning methods, one main weakness of the lecture method is that it allows students to be passive recipients of information that has been "prepared" by the professor (Hansen & Stephens, 2000, p. 42). Thus, students become dependent on the professor to tell them what they need to know and can avoid taking responsibility for their own learning (Covill, 2011). Further, students accustomed to being passive have a "low tolerance for challenge" (Hansen & Stephens, 2000, p. 46). Finally, according to active learning activists, learning as a result of lectures is relatively superficial and transient (Moust, Van Berkel, & Schmidt, 2005).

Furthermore, Jagero, Mkitaswidu, Beinomugisha and Rwahsema (2012) lamented that, this strategy is unhelpful for students who are poor in note-taking skills and disadvantaged students (handicapped students). It is a mistake to assume all college students are competent note-takers.

The recommendation to use active methods is made even though research is mixed as to the effectiveness of these methods. Some research suggests that, compared to the lecture method, methods that promote active learning increase student achievement (O' Sullivan & Copper, 2003; Christianson & Fisher, 1999), student participation (McClanahan & McClanahan, 2002), and retention of concepts over time .

Other research indicates that the lecture method is superior (Struyven, Dochy, & Janssen‟s, 2008), or at least comparable (Van Dijk, Van Den Berg, & Van Keulen, 2001), based on several assessments, including student learning. It may be that the lecture method is effective for teachers who lecture well, and active methods are effective for teachers who are adept at developing meaningful in-class activities. Tomlinson and Allan (2000) showed skepticism on the usefulness of the lecturing teaching strategy. The researcher agrees that lecturing minimizes feedback from students, assumes an unrealistic levelof students‟ understanding and comprehension, and often disengages students from the learning process. Consequently, causing information learnt to be quickly forgotten.

Norris and Barnett (1994) argued that, the lecture strategy could cause students to miss the important points of the content as he might consider that everything the lecturer says is important. It may happen sometimes lecturers go off-track from their primary objectives for the class session. In addition, lecture-teaching strategy may lead to passive learning since students have no chance to give their contributions On how to make the lecture more effective, Marmah (2014) recommended that lecturers fit lectures to the audience, focus on the main points of the topics and organize the points for clarity. Also, lecturers should select appropriate examples or illustrations, present more than one side of an issue and be sensitive to other perspectives, repeat points when necessary, be aware of the audience by noticing their feedback and be enthusiastic.

Marmah (2014) recommended that lectures should be presented in way that fits its audience, focusing on the topic, pinpoints the specific areas of concentration and precisely organization with clear examples. The researcher adds that sensitive issues, stressing on the key points and getting feedback from the audiences are of overriding importance for effective and efficient teaching through the lecture strategy.

2.4 Gender and Science Learning

Gender is an identifiable student characteristic that might determine or affect their achievement in science (Mwetulundila, 2001). Cheel (1987) argued that while a student's sex is not in itself a determinant of achievement, the differences in achievement between girls and boys, particularly in the physical sciences, is well researched and documented. Kotte (1992) contended that the differential expectations and socialization that boys and girls undergo are responsible for the gender differences in school subjects. Concern over the societal status of women has been in existence for a long time, although the concern over low participation and performance of women in science and mathematics has peaked in recent years (Plucker, 1996).

Gender differences have been noted in a number of national and cross-national research studies (Keeves, 1973; Kotte, 1992; Postlethwaite & Wiley, 1992). An initial explanation given for these findings, although not by those authors, was that girls were inherently unable to do well on the spatial problems that are present in the learning of chemistry and physics. Kotte (1992), for instance, argued that girls' under-achievements in science were due to biological factors. Studies further show that the parts of the brain responsible for processing verbal information and permitting the exchange of information between hemispheres were more highly developed in girls (Kimura, 2005). Girls also demonstrated earlier development in the brain regions responsible for impulse control, and, in general, matured earlier than boys (Olasehinde & Olatoye, 2014). However, the extent to which these biological differences manifested themselves in behavioural differences and their implications for learning was unknown. However, recent research has dismissed this as an inappropriate explanation, and researchers have focused on cultural or social factors such as attitudes. Also research conducted by Abdulraheem et al. (2012) showed that gender was not influenced by the teaching method, in students‟ achievement in the mole concept. Researchers had also tried to find out the instrument that can best determine the achievement of participants in a mole concept.

2.5 Pre-Test and Post-Test

McMillan and Schumacher (2010) indicated that the term test refers to the use of test scores as data. This technique was used as the research participants‟ responded to written questions to measure their performance trait. But pre-test in research can simultaneously generate threats to the internal validity of the research. In other words, pre-testing causes its own threats to internal validity in addition to supporting the internal validity of the intervention effect. Pre-test sensitization effects (or pre-test effects, in short), a term coined by Campbell and Stanley (1963), are confounded with the effect of treatment and without caution are often ignored during the conduct of a research study. Without evaluating the pre-test sensitization effect in an appropriate way, the use of pretests can result in misinterpreted results. The issues of pretest sensitization effects have been addressed over the past 45 years. However, as Kim and Willson (2010) articulated, there is a dearth of follow-up research on this topic since Willson and Putnam (1982) meta-analysis on pre-test sensitization effects. Furthermore, there has been little apparent application of the findings of that meta-analysis to experimental research involving pretests. The purposes of this research are (a) to examine whether researchers deal with the pretest sensitization effects experimentally, (b) to use the results of the Willson and Putnam meta-analysis to demonstrate how to take account of pre-test effects in data analysis for two illustrative research studies, and (c) to propose procedures for applying the meta-analysis results to experimental studies employing pretests as a theoretical exercise. We finish by suggesting that meta-analysis findings in substantive research should take on the role commonly found in various physical sciences as a starting theory for interpreting new results.

Pre-test sensitization refers to ,,,the potential or actuality of a pretreatment assessment‟s effect on subjects in an experiment"" (Kim & Willson, 2010). Pre-tests may increase (or decrease, depending on the characteristics of the test) scores at post-test not only for the same or similar scales but also for dissimilar scales in which the constructs may be completely different. Whatever the usage of the pre-test in research is, the presence of pretest can alter the nature of the intervention and consequently cause problems in measuring the treatment effect per se. Pre-test effects are explained by some researchers as a motivational factor or a direct teaching function (Kim & Willson 2010). In general, pretests may enhance arousal or increased attention to the coming events such as treatment and post-test. Pretests may alert the subjects to the relevant topics and direct the subjects" attention selectively to what the researchers intended to look at. This arousal to the intervention or posttest, regardless of whether it is general or specific, performs differently under various conditions of research. For example, Willson and Putnam (1982) reported that the pre-test effects on cognitive outcomes are on average greater than those on affective measurements. Moreover, it was noted that pretest effects vary with the characteristics of subjects (e.g., age and ability level) as well as the characteristics of testing (e.g., duration between pretest and pos-test; Willson & Putnam, 1982). Hence, these study characteristics are typically included for consideration in pretest studies. In accordance with Willson and Putnam‟s (1982) meta-analysis, the current study takes types of measures, duration between pre- test and post-test, similarity of pretest and posttest, and subjects‟‟ mean age into account in the procedures advocated.

With the popularity of the pre-test–post-test control group design, the statistical methods required to properly operationalise the design have been of concern to many researchers as well. Several statistical approaches are commonly practiced in the pretest–posttest design research: (a) analysis of variance (ANOVA) on the difference (also called gain or change) scores, (b) a two-way repeated-measures ANOVA, and (c) t-test (Dugard & Todman, 2001). But due to effectiveness of t-test, the researcher used it for the data analysis procedure.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the procedures that were used to conduct the study. It focuses on the study area, research design, population, sample and sampling techniques, instrumentation, validity and reliability of the instruments, pre-intervention, intervention, post-intervention, and analysis of data.

3.1 Description of the Research Area

The study was carried out at Techiman Senior High School, Techiman-South in the Brong East region of Ghana. The school is at the southern of Techiman Township, opposite the Techiman amanfomu. From Techiman going to Kumasi, the school is at the right hand side of the road about ten minutes drive from the Techiman Township. When coming from Kumasi, the school is at the left side of the road, about ten minutes drive to the Techiman Township.

3.2 Design of the Study

The research design was an educational action research. An educational action research is a process in which participants examine their own educational practice systematically and carefully, using the techniques of research (Zohar & Dori, 2003).

Individual teacher research usually focuses on a single issue in the classroom (Zohar & Dori, 2003). Educational action research was considered because it was the best design to establish the effectiveness of problem-based learning approach to mole concept. Also, since the design allows for control variables, the outcome could be reliable and well suited for generalization. Intact or already existing classrooms were used for the study. The experimental group was the group taught with the PBL which is an independent variable and the control group was the group taught with the TLB which is also an independent variable. Before both groups were taught with the PBL and the TLB approaches, each group received the Mole Concept Achievement Test (MCAT) in the form of pre-test which is a dependent variable. The MCAT in the form of post-test which is also a dependent variable was administered on both the experimental and control groups after they were taught with the PBL and TLB approaches

3.3 Population

The target population for the research was the entire second year science students in Techiman Senior High School, made up of two hundred and forty three (243) students.

3.4 Sample and Sampling Technique

The sample size was seventy-four (74) second year students offering science Programme. The control group (2S2) consisted of thirty-seven (37) second year science students made up of thirty-one (31) boys and six (6) girls and the experimental group (2S1) was equally thirty-seven (37) second year students made up of twenty nine (29) boys and eight (8) girls as this arrangement was the prevailing situation in the two intact classes at the time the study was conducted. To address the stated research questions, the sampling procedure therefore was purposive. Teddlie and Yu (2007) define purposive sampling technique as “selecting units (individuals, groups of individuals, institutions, etc) based on specific purposes associated with answering a research study‟s questions”.

3.5 Instrumentation

The main research instrument used for the study was the Mole Concept Achievement Test (MCAT). This took the form of pre-test and post-test. McMillan and Schumacher (2010) indicated that the term test refers to the use of test scores as data. This technique was used as the research participants‟ responded to written questions to measure their performance trait. A numerical value was obtained as a result of each participant‟s answers to a standard set of questions. The instrument was used as a way to determine the achievement of the participants. A description of each of these follows.

3.5.1 Pre-test and post-test

The pre-test was aimed at finding common mistakes the students committed when solving mole concept questions. The pre-test was used during the pre-intervention stage. After the intervention, a set of similar questions (post-test) was given to students to check whether they had grasped the concepts. The pre-test and post-test were similar in structure. The test items were written to include four concepts of working with the 'mole'. The first concept was the application of terminology and the use of definitions (questions 1, 3, & 4), the second was calculating the molar mass from a written compound (questions 2, & 6), the third concept involved calculating the number of moles from a gram sample (questions 5 & 7) and the final portion of the test were written to challenge the students' knowledge of the mole concept by using Avogadro's constant calculating molar mass and finding a mass using a mole quantity (questions 8, & 9).

The pre-test and post test consisted of nine (9) questions each and marked over 30 marks. Each correct item for question 1, 3, & 4 carried two (2) mark a total of two and half (6) marks. Each correct item for question 2 & 6 carried three (3) marks a total of eight (6) marks. Question 5 & 7 carried a total of eight (8) marks. Question 8, & 9 carried total marks of ten and half (10). The total score for pre-test and post-test was 30 marks each. Samples of pre-test and post-test questions can be found in Appendices A and C respectively.

3.6 Validity of the Instruments

Lederman, Abd-El-Khalick, Bell, and Schwartz (2002), defined validity of an instrument as the extent to which the instrument measures what it is intended to measure. To ensure validity of the instruments, two types of validity were addressed. These include face validity and content validity. Face validity was achieved through inspection by the researcher"s Head of Science Department at the school and two other chemistry teachers to read through to prevent any ambiguity in the questions. The content validity of the instrument was achieved through piloting and weakness identified corrected.

3.7 Reliability of the Instruments

Reliability is an essential characteristic of a good test, because if a test does not measure consistency, then one could not count on the scores resulting from a particular administration to be an accurate index of students" achievement. The instrument developed for the study was once again subjected to scrutiny by given it to my supervisor for another proof reading to make sure that the test items were made clearer and unambiguous. The reliability of the instrument was tested using second year 2S3 students which have similar characteristics to 2S1 and 2S2 where the study was carried out. The reliability coefficients were found to be 0.736 and 0.751 for the pre-test and post-test respectively.

3.8 Pre- intervention Data Collection

Data collection began during the period of my teaching, after interacting with the class and identifying a topic for the study. The pre-test questions were distributed to both the control and experimental groups before treatment. The students were instructed to answer all the questions. The questions were answered under the supervision of the researcher to ensure that students worked independently. The test items comprised of nine questions and marked over 30 marks. The following were some of the errors the researcher observed after marking the pre test:

The researcher observed that students had difficulties piecing together the atomic ratio, mass ratio and the molar mass ratio. The students equated the mass ratio with the mol (atom) ratio. For item 2 this would mean:

$m(Cu) : m(S) = n(Cu) : n(S) = 1 : 2$

Students dividing the 6 g copper sulfide in the relation 1 : 2 which led to the incorrect result of 4 g of sulfur.

Another (less frequent) error observed was that students equated the mass ratio with the ratio of molar masses.

$M\ (Cu): M(S) = M\ (Cu) : M(S) = 2 : 1$

Students divided the 6 g copper sulfide in the relation 2: 1 which arrived at incorrect result 2 g of sulfur.

3.9 Intervention Activities

The outcome of the pre-intervention activities required an intervention to help the students to write and balance chemical equation correctly. The intervention activities were implemented within three weeks schedule. The experimental group was subjected to instruction on the mole concept using problem-based learning (PBL).

While the control group taught the same concept using the Traditional lecture-Based approach (TLB).

Control group: The first week of the study, the mole concept was introduced using a traditional style of teaching. While information was presented in a lecture-style format, students took notes and participated in any discussion that may arise. They were given an assignment from their textbook in which they answered questions and solved 'mole' calculations. On second week, students continued working on calculations. On the third week, preparation of standard solution and calculation of amount of substance concentration and mass concentration of the solution were outline on board. On the fourth week, students took the Mole Concept Achievement Test (MCAT), written by the instructor, which was designed to measure student knowledge of the 'mole'.

Experimental group: On the first week of the study, the mole concept was introduced using problem-based activity. Students were asked to define the term “mole”. Students followed the directions of the activity, and the instructor observed and answered any questions. The instructor facilitated discussions involving open-ended questions such as “why chemists do not count atoms and molecules directly?” and encouraged the students to actively engage in researching further to answer these questions. The students were assigned problems from the activity, which included calculations using the 'mole'. On the second week, students were provided with the opportunity to ask questions regarding the concepts and then continue working on calculations. Multiple choice items were developed that were easily solved without arithmetical calculations and without a calculator. To make this possible, students were advised to rounded off the relative atomic masses (or molar masses) of the elements to whole numbers. The problems were based on binary compounds of the elements which had a mass ratio of 1: 1 and a simple atomic (molar) mass ratio such as 2 : 1, 3 : 1. The rounded atomic (molar) masses were given in brackets as illustrated below.

Li (7), N (14)

C (12), Mg (24), Cl (36), Ti (48)

O (16), S (32), Ti (48), Cu (64), Mo (96), Te (128)

Item 2 illustrated problems of this type.

The chemical formula of copper sulfide is CuS_2. What mass of sulfur would be found in 6 g of copper sulfide?

[A] 1.5 g, [B] 2 g, [C] 3 g, [D] 4 g

In that case the atomic (molar) mass ratio M (Cu): M (S) was 64 g/mol : 32 g/mol = 2: 1, the mass ratio m(Cu) : m(S)= 1 : 1.

The researcher observed that students used three strategies to solve the problems. These were illustrated with reference to item 2:

Strategy 1 (mole method):

1. Calculate the molar mass of the compound

$M(CuS_2) = 128$ g/mol

2. Calculate the amount of substance of the compound

$n(CuS_2) = 6$ g / (128 g/mol) = (6/128) mol.

3. Determine the amount of substance of the element whose mass is requested

1 mol CuS_2 contains 2 moles S

n(S) = (12/128) mol S.

4. Calculate the mass of sulfur m(S)

$m(S) = n(S) \times M(S) = (12/128)\ mol \times 32\ g/mol\ S = 3\ g\ S$

Typical of strategy 1 are steps 2 and 3 describing the relations between given and required substance via amount of substance.

Strategy 2 (proportionality method):

1. Calculate the molar mass of the compound

$M(CuS_2) = 128\ g/mol$

2. Formulate the ratio between masses and molar masses (one mole CuS_2 consists of one mole Cu and two moles of S:

$$\frac{M(CuS)}{M(CuS)} = \frac{2M(S)}{m(S)2}$$

3. Transform the ratio to

m (S) =…. .

4. Calculate the mass requested

$$m(S) = \frac{2 \times 128 g / mol}{32 g / mol} \times 6\ g\ S$$

=3g S

Strategy 3 (.logical method.)

1. The molar (atomic) mass ratio of copper to sulfur

M(Cu) : M(S) is 2 : 1

i.e. two atoms of sulfur have the same mass as one atom of copper.

2. The atom ratio of copper to sulfur n(Cu) : n(S) is conversely 1 : 2

3.Consequently the mass ratio of copper to sulfur,

m(Cu) : m(S), is 1 : .1

4. Dividing the 6 g of copper sulfide into two halves leads to 3 g sulfur.

On the third week, in heterogeneous groups of four (4), the researcher engaged the students in practical work at the laboratory and then guided them to prepare standard solution and calculate amount of substance concentration and mass concentration of the solution. On the fourth week, students took the same Mole Concept Achievement Test (MCAT) administered to the control group.

3.10 Post-Intervention Activities

At the end of the four (4) weeks treatment period, the two groups were post-tested. The pre-test and post-test were similar in content. The purpose of this test was to determine the effectiveness of Problem-Based Learning of the two groups. The students were instructed to answer all the questions. The questions were answered under the supervision of the researcher and the Head of Department to ensure that students worked independently. The test items comprised of nine (9) questions and marked over 30 marks.

3.11 Data Analysis Procedure

The data collected from the pre-test and post-test were analyzed using bar chart, mean, standard deviation and t-test. Data were analysed according to the research questions. Mean scores and standard deviations were determined from the pre-test and post-test. Research questions were formulated into hypotheses and analysed using Statistical Package for Social Science (SPSS) version 16.0. T-test for dependent samples was used to investigate any differences that existed between the experimental and control groups in performance at 0.05 alpha level at alpha significant level of 0.05. Most behavioural scientist agree that alpha significant level of 0.05 is reasonable to used in a research (Duffy, 2010).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter deals with the presentation of the pre-intervention results, followed by that of post-intervention results that were obtained from the study. It further discusses the results of the study and its relation to the research questions.

4.1 Results of Pre- Intervention Test

The pre-intervention test results are presented in Table 1 and 2. It was primarily aimed at finding the performance for both control and experimental group before the intervention.

Table 1: Distribution of Pre-test of both Control and Experimental group

MARKS OBTAINED	NO. OF STUDENTS (CONTROL)	Marks obtained (%)	NO. OF STUDENTS (EXPERIMENTAL)	Marks obtained (%)
0 - 5	10	27	9	24
6 - 10	12	32	12	32
11 - 15	9	24	11	30
16 - 20	5	14	4	11
21 - 30	1	3	1	3
Total	**37**	**100**	**37**	**100**

Source: Field Data, 2019

A Bar chart showing test scores of students in the control and experimental groups for pre-test are presented in the Figure 1.

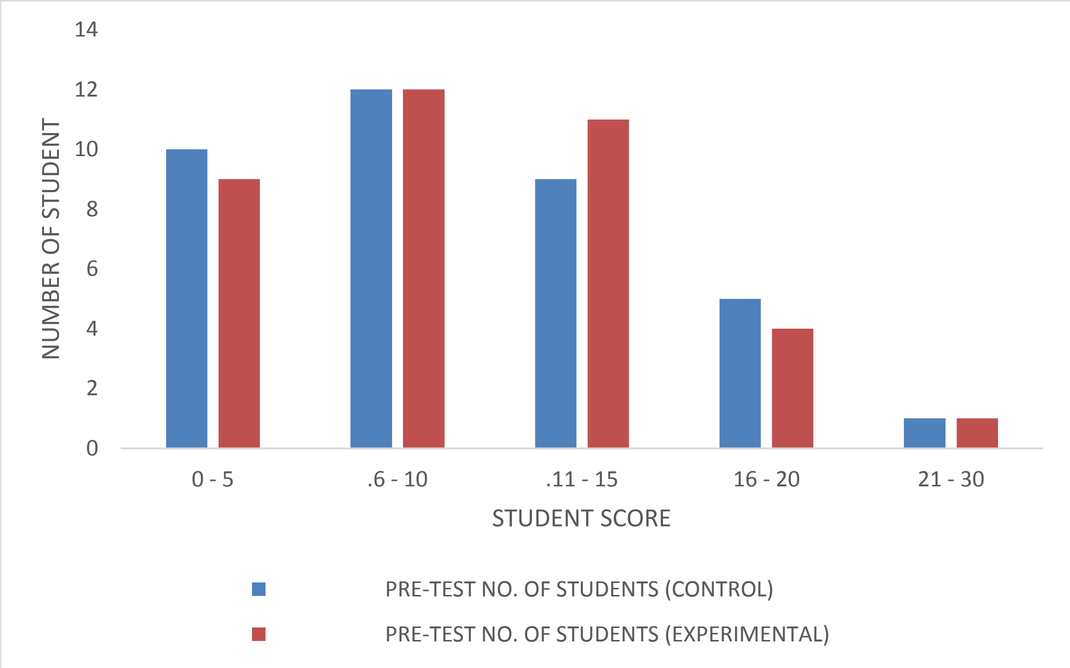

Figure 1: Bar Chart Showing Test Scores of Students in the Control and experimental Groups for Pre-test.

The results (Table 1) revealed that ten (10) representing 27% and nine (9) students representing 24% in the control and experimental groups respectively obtained total scores within the range of 1-5. Twelve (12) students representing 32% in the control group and twelve (12) students representing 32% in the experimental group had their total scores within the range of 6-10. Also nine (9) students representing 24% in the control group and eleven (11) students representing 30% in the experimental group obtained total scores within the range of 11-15. Within the range of 16-20 scores, five (5) representing 14% and four (4) students representing 11% in the control and experimental groups respectively got their scores in that range. Only one (1) student representing 3% in the control group and one (1) student representing 3% in the experimental group obtained a total score within a range of 21-30. The results showed that sixty three (63) of the students representing 85%, thirty one (31) students representing 42% in the control group and thirty two (32) students representing 43% in the experimental group, out of a total of seventy four (74) students selected for the study obtained scores starting from 1 to 15 marks. Just eleven (11) students representing 15%, six (6) representing 8% in the control group and five (5) representing 7% in the experimental group out of a total of seventy-four (74) students had scores above fifteen (15).

The bar chart in Figure 2 above compared the test scores of students in control and experimental group for pre-test. The results showed that students performance were almost the same.

Also, the pre-test scores of both the experimental and control groups were compared using the unpaired t-test to find out if there was any significant difference between the achievements of the two groups in the mole concept. This is because the results presented using the chart does not tell the difference in achievement between the two groups even though a particular trend is being shown.

Table 2: Unpaired Samples t-test of Pre-test Scores of Experimental and Control Groups

Group	N	M	SD	df	t-value	p-value
Experimental	37	9.11	5.36	72.00.	1.99	0.93
Control	37	9.00	5.29			

Source: Field Data, 2019

Table 2, shows an independent sample t-test which was conducted to compare the achievement of Pre-test Scores of Experimental and Control Groups before problem-based learning strategy. The scores obtained were experimental group (mean = 9.11, SD=5.36) and control group (mean = 9.00, SD = 5.29) respectively. The value of t-calculated was 1.99 at $P > 0.05$ and df of 72. The results (Table 1) revealed that there was no significant difference between the mean scores of the two groups (experimental and control) before the treatments using PBL and TLB approaches (p = 0. 93) and hence, the researcher fail to reject the null hypothesis 1.

4.2 Results of Post- Intervention Test

The post-intervention test results are presented in Table 3 and 4. It was primarily aimed at finding the performance for both control and experimental group after the intervention.

Table 3: Distribution of Post-Test of Both Control and Experimental Group

MARKS OBTAINED	NO. OF STUDENTS (CONTROL)	Marks obtained (%)	NO. OF STUDENTS (EXPERIMENTAL)	Marks obtained (%)
0 - 5	8	22	0	0
.6 - 10	10	27	0	0
.11 - 15	10	27	2	5
16 - 20	6	16	7	19
21 - 30	3	8	28	76
Total	**100**	**37**	**37**	**100**

Source: Field Data, 2019

A bar chart showing test scores of students in the control group for pre-test and post-test are presented in Figure 2 below.

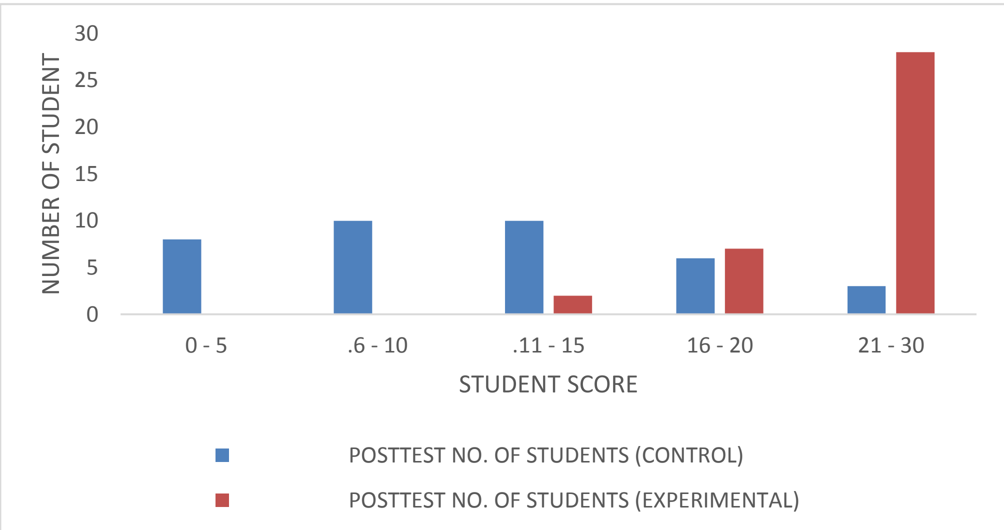

Figure 2: Bar Chart Showing Test Scores of Students in the Control Group for Pre-test and Post-test

Considering the results of the study (Table 3), whereas in the control group eight (8) representing 22% , ten (10) representing 27% and ten (10) representing 27% students obtained total test scores within the ranges of 1-5, 6-10 and 11-15 respectively, no student representing 0% had a total score within the ranges of 1-5 and 6-10 in the experimental group. Only two (2) students representing 5% got their total scores within the range of 11-15. Six (6) representing 16% and seven (7) representing 19% students had their total scores within the range of 16-20 in the control and experimental groups respectively. On the other hand, as many as twenty eight (28) students representing 76% (out of a total of thirty- seven) obtained total scores within the range of 21-30 in the experimental group while in the control group only three (3) students representing 8% (out of a total of thirty- seven) had total scores within that same range. Comparatively, nine (9) students representing 24% obtained total scores above fifteen (the pass mark) in the control group, whilst as many as thirty –five (35) students representing 95% got total scores above fifteen in the experimental group.

The bar chart in Figure 2 above compared the test scores of students in control and experimental group for post-test. The results showed that students in the experimental group performed better than control group.

The unpaired samples t-test was used to determine the difference in achievement in the mole concept between the students in the experimental and control groups using the PBL approach and the TLB method respectively. The results indicated that the students in the experimental group had higher achievement in the mole concept than their control group counterparts since the mean score of the experimental group was significantly higher than the mean score of the control group (p $=1.2\times10^{-15}$). The results revealed that the treatment using PBL yielded significantly higher achievement of students in the mole concept than the treatment using the TLB approach (Table 4)

Table 4: Unpaired Samples t-test of Post-test Scores of Experimental and Control Groups

Group	N	M	SD	df	t-value	p-value
Experimental	37	22.49	4.24	72	1.99	1.2×10^{-15}
Control	37	10.51	5.73			

P<0.05, df = 72

Source: Field Data, 2019

In Table 2, an independent t-test was conducted to compare the effect of problem-based learning approach and lecture instructional strategies. The different scores for problem-based (mean = 22.49, SD = 4.24) and lecture method (means 10.51, SD = 5.73) at P < 0.05, and df of 72 and hence, hypothesis 1 was rejected.

The unpaired samples t-test was used to determine the difference between mean scores of male and female students" on post-test score in the mole concept after exposure to problem-based strategy.

Table 5: t-test analysis of the influence of gender on students' post-test achievement scores after exposing them to problem- Based learning Approach

Group	N	X	SD	t-critical	t-stat
male	29	22.50	4.00	1.69	0.03
Female	8	22.50	5.00		

Source: Field Data, 2019

Table 5, shows an independent sample t-test which was conducted to compare the achievement of male and female students" after exposing them to problem- based instructional strategy. The scores obtained were male (mean = 22.5, SD 4.00) and female (mean = 22.5, SD = 5.00) respectively. The value of t-calculated (0.03) was less than the t-critical (2.02) at P <0.05 and df of 35. Hence, there is no significant difference and therefore the researcher fail to reject the null hypothesis 3.

4.3 Discussion

Research Question 1: What is the difference in achievement of the students in the mole concept in the experimental and control groups before the treatments using PBL and TLB approaches respectively?

This research question sought to find out the achievement of the students in the mole concept in both the experimental and control groups before the treatment. The achievement of the students in the mole concept before the treatment was determined by using the students‟ pre-test scores. The pre-test was scored out of a total of thirty points in both the experimental and control groups. The pass mark (baseline) that determined whether a student failed or passed the test was fifteen. A student whose total score was below fifteen failed the test and those who scores were exactly fifteen or above passed the test.

The fact that there was no significant difference between the two groups meant that the students‟ achievement in the mole concept before the treatments using PBL and TLB approaches was the same. Interestingly these were students taught by different teachers when they were in first year, yet the study indicated that their level of achievement in the mole concept was the same. This meant that the students, irrespective of which class they were coming from, had common difficulties in understanding the mole concept. The low achievement of the students in the mole concept at the pre-test level could be attributed to the abstract nature of the mole concept, hence the difficulties for the students to attain high achievement. The results of the study therefore support a study by Fach, De Boer and Parchmann (2007) which contends that students have acute difficulties in dealing with the abstract concepts required of them to perform stoichiometric calculations using the mole concept.

Apart from finding out whether there was any significant difference between the two groups in terms of the students" achievement in the mole concept base on their previous knowledge, the results of the study also formed the baseline for determining the effectiveness of the PBL approach on the students" achievement in the mole concept. The baseline in terms of achievement between the two groups was statistically the same. This therefore formed the basis for using the two groups as the experimental and the control groups. The pre-test questions on the mole concept were basic questions derived from both the Senior High School integrated science syllabus and WASSCE past questions . The questions basically centred on the definition of mole of a substance, its unit of measurement, definitions of molar mass and molar volume and their units of measurement. The rest of the questions were calculations on mole conversion that involves mass of a substance, molar mass, number of particles (atoms, molecules), the Avogadro"s number, molar concentration and molar volume. Although the questions were basic which the students were supposed to have learnt at the Senior High School level, their achievement was low and that clearly indicated that they really had problems learning the mole concept.

Research question 2: What is the difference in achievement of the students in the mole concept in the experimental and control groups after the treatments using the PBL and the TLB approaches respectively?

This question aimed at comparing the achievement of the students in the mole concept using two teaching approaches (PBL and TLB). The main aim was to determine the effect of PBL on the students" achievement in the mole concept. The two treatments PBL and TLB were carried out in the experimental and control groups respectively.

The results of the study in general revealed that the students who were taught with the PBL approach in the mole concept did significantly better than those taught with the TLB method. The PBL has proved more effective in improving the students" achievement in the mole concept than the TLB. The students" achievement in the posttest in the mole concept in the experimental group was significantly higher than those in the control group. The results were in line with a study by Dannawi (2013), which indicated that students taught using the problem solving approach perform significantly better than those taught using the lecture method approach. The results also confirmed Shehu (2015), a study conducted on the effect of problem-based instructional strategies on students" learning outcomes in Senior Secondary School chemistry, revealing that students taught using problem-solving perform significantly better than those taught through lecture method in improving students" achievement in the mole concept. Within the same group (experimental group), the post test results were comparatively better than the pre-test results attesting to the effectiveness of the PBL in yielding better achievement among students in the mole concept. On the contrary, the students taught with the TLB showed lower achievement in the mole concept compared to those taught with PBL. No wonder studies showed that problem-based is a prominent feature in the learning of science and its neglect could have negative effect on students' learning outcome in the sciences (West, 1992). According to Fatoke and Olaoluwa (2014), the conventional lecture method of teaching chemistry proved less effective than the problem-based method. One of the reasons for the better achievement in the mole concept using the PBL over the TLB confirmed a study by Raimi and Adeoye (2004), which contend that the superiority of problem based learning strategy over the conventional method could be attributed to the logical and sequential manner with which instructions are presented in problem based technique and practical skills teaching. The rather low achievement of the students in the mole concept as they were taught using the TLB supports a study by Hirca (2011), that argued that in traditional science lessons, teachers come to teach and students memorise or mimic their acts without understanding and retaining whatever that is being taught.

The students" application of knowledge, problem-solving skills, higher-order thinking, and self-directed learning skills in the PBL under this study resulted in their higher achievement in the mole concept than those taught with the TLB. This agrees with the study of Hung (2009), which asserted that problem-based learning (PBL) appears to be the most innovative instructional method conceived and implemented in education with the aim of enhancing students" application of knowledge, problem solving skills, higher-order thinking, and self-directed learning skills. In PBL, students worked in groups, had the opportunity to solve several questions and direct their own learning as opposed to TLB where students were simply given lectures with no room for working in groups as well as direct their own learning. The achievement of the students in the mole concept in the experimental group using the PBL approach confirms the study of Savery (2006), which observed that PBL is an instructional approach that has been used successfully for over 30 years and continues to gain acceptance in multiple disciplines. In the PBL, the learners were placed in the centre of the learning process with the teacher‟s role being a facilitator. With worksheets on various aspects of the mole concept, the students in groups solved several questions that yielded a better post-test achievement in the mole concept than those treated with TLB. The advantage of working in groups as in the context of PBL aided the students to perform better than their counterparts who were exposed to the TLB where working in groups was less emphasized. There was similarity between the better achievement of the students in the mole concept as a result of PBL and the study of Burke (2011) on advantages of working in groups, emphasising that groups stimulate creativity, help people remember group discussions better, foster learning and comprehension and decisions that students help make yield greater satisfaction. The results of the study also agree with the study of Akar (2005), which posited that the constructivist approach to teaching enables students to perform better in chemistry achievement test than the traditional lecture method. This is because the students in the constructivist group have the opportunity to benefit from discussion and interaction with peers than the traditional lecture method.

Research question 3: What will be the gender influence on students' achievement in the mole concept after exposure to problem-based learning approach?

This study showed that gender was not influenced by the teaching method, in students‟ achievement in the mole concept. Table 3 shows equal performance of male and female when both were taught the mole concept with problem-solving approach (male X = 22.50, female X = 22.50). These revealed that there was no significant difference between the achievement of male and female students‟ as found in hypothesis 2. This result was in agreement with the findings of Abdul-Raheem (2012). However, the result did not agree with those of Mwetulundila, (2001), Changeiywo, (2000), whose works revealed a significant different in the performance of male and female students in favour of male. In addition, there was no significant difference in performance with respect to gender among students in descriptive, mathematical and spatial ability areas. The findings of this study strongly disagrees with that of Gabel and Sherwood (1984) who concluded that the problem students encounter in the mole concept was as a result of the lack of mathematics content skills involved in the study of this topic. The findings further show that there is no significant difference between male and female students‟ attitude to science which contradicts Olasehinde and Olatoye (2014) that reported significant difference between male and female students in attitude to science

CHAPTER FIVE

FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.0 Overview

This chapter focuses on the major findings, conclusion, and recommendations of the study.

5.1 Major Findings

The following are the major findings of the research.

- The pre-intervention findings were that the long practiced teaching approach referred to as the traditional lecture-based method does not improve the achievement of the students in the mole concept as the study results indicated that the students had low achievement in the mole concept when taught with the TLB approach as evidenced by the content of Table 4. With this approach, the teacher dominates in the teaching and learning process. Students are denied small group approach to learning and instead of students constructing their own meanings of concepts learnt, they are forced to memorise these concepts with limited or without understanding.
- The post-intervention findings revealed that the treatment using PBL yielded significantly higher achievement of students in the mole concept than the treatment using the TLB approach. In PBL, learning is carried out among students in small groups where there is sharing of ideas among group members in the form of discussion which creates room for all members to benefit from whatever is being discussed. Students construct their own meanings of the concepts learnt with high level of retention. Students are self-directed and

acquired problem solving skills to learn among themselves with limited guidance by the teacher, who serves as a facilitator.

5.2 Conclusion

A critical look at the research findings makes it clear that in the PBL, the learners were placed in the centre of the learning process with the teacher‟s role being a facilitator. With worksheets on various aspects of the mole concept, the students in groups solved several questions that yielded a better post-test achievement in the mole concept than those treated with TLB. The advantage of working in groups as in the context of PBL aided the students to perform better than their counterparts who were exposed to the TLB where working in groups was less emphasized. There was similarity between the better achievement of the students in the mole concept as a result of PBL and the study of Burke (2011) on advantages of working in groups, emphasising that groups stimulate creativity, help people remember group discussions better, foster learning and comprehension and decisions that students help make yield greater satisfaction. The results of the study also agree with the study of Akar (2005), which posited that the constructivist approach to teaching enables students to perform better in chemistry achievement test than the traditional lecture method. This is because the students in the constructivist group have the opportunity to benefit from discussion and interaction with peers than the traditional lecture method.

5.3 Recommendations

Based on the outcome of the study and conclusion drawn, the researcher made the following recommendations:

- Chemistry teachers at Techimen SHS should try to use various teaching strategies including PBL approach designed by curriculum planners in the syllabus for students to understand the contents better.
- Teachers should identify appropriate and relevant teaching-learning materials for any lesson they teach. The use of appropriate and relevant teaching-learning materials arouses the interest of students.
- Teachers should help students appreciate that mole concept is very easy subject to learn, and science is found in their environments, and even in their houses. This could be done by involving the students in every science activity to allow them discover things by themselves which would in turn help erase the perception that, science is a difficult subject.

5.4 Suggestions for Future Research

Based on the findings of the study, the following suggestion for further researching is made.

- Curriculum planners should design chemistry syllabus in a way that, there will be more practical activities to the theory aspect.
- Ghana Education Service and Heads of schools should make funds available for schools to buy teaching and learning materials on time.
- Government should provide schools with libraries and stock them with books; also laboratories with them stocked science equipment.
- Regular In-Service training should be organized for chemistry teachers to acquaint themselves with the current developments in the teaching and learning strategies of chemistry.

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APPENDIX A

PRE-TEST QUESTIONS

TECHIMAN SENIOR HIGH SCHOOL, TECHIMAN SOUTH-BONO EAST

This test is only for research purpose, any information you provide will not be used against you. Circle the letter of the term or phrase that completes the statement or answers the question.

CODE --------------------- **SEX**...............

1. The number of atoms of each element in a molecule is shown in a(n)

[A] Empirical formula [B] molecular formula [C] mole [D] molecular mass

2. The chemical formula of copper sulfide is CuS_2. What mass of sulfur would be found in 6 g of copper sulfide?

[A] 1.5 g, [B] 2 g, [C] 3 g, [D] 4 g

3. What do you need to know in order to figure out the mass of a mole of any compound?

4. Define the term mole.

5. The number of moles represented by 23.0 grams of nitrogen dioxide, NO_2, is

[A]. 0.500 [B] 1.00 [C] 2.00 [D] 3.00

6. What is the molar mass of sodium sulfate, Na_2SO_4 ?

[A] 142.06 g [B] 86.99 g [C] 1 09.98 g [D] 70.99 g

7. The number of moles represented by 252.06 g of baking soda, $NaHCO_3$, is

[A] 5.00 [B] 3.00 [C] 2.00 [D] 1.00

8. What is the mass of 1.50 x 10^{23} molecules of cane sugar ($C_{12}H_{22}O_{11}$)?

[A] 513 g [B] 85.6 g [C] 342 g [D] 1370 g

9. Calculate the molar mass of each of the following moles of substances

a) 1.85 moles $MgCl_2$ b) 2.50 moles $Cu(OH)_2$

APPENDIX B

POST-TEST QUESTIONS

TECHIMAN SENIOR HIGH SCHOOL, TECHIMAN SOUTH-BONO EAST

This test is only for research purpose, any information you provide will not be used against you. Circle the letter of the term or phrase that completes the statement or answers the question.

CODE --------------------- **SEX**...............

1. The sum of the atomic masses of all atoms in the formula unit of an ionic compound is the

[A] atomic density [B] molecular mass [C] ionic mass [D] formula mass

2. The molar mass of Magnesium Chloride, MgCl , is

[A] 59.8 g [B] . 95.2 g [C] 125.8 g [D] 76.4 g

3. Which of the following units is used to represent the chemical quantity of a substance as a number of particles?

[A] kilogram [B] ampere [C] gross [D] mole

4. Which of the following statements explains why chemists do not count atoms and molecules directly?

[A] Matter is neither created or nor destroyed in a chemical reaction.

[B] All of the relationships in a chemical reaction can be expressed as mass ratios.

[C] Atoms and molecules are extremely small.

[D] Reactions occur one atom at a time.

5. Calculate the number of moles of each of substance from each of the following masses given

a) 15.0 g of Carbon dioxide, CO_2

b) 50.0 g of Aluminum sulfate, $Al_2(SO_4)_3$

6. What is the molar mass of baking soda, $NaHCO_3$,

[A] 52.02 g [B] 108.04 g [C]. 156.06 g [D]. 84.02 g

7 Explain which has more mass, 1 mole of Oxygen molecules, O_2 , or 1 mole of aluminum atoms, Al ?

8. What is the mass of 1.50 x 10^{23} molecules of cane sugar ($C_{12}H_{22}O_{II}$)?

[A] 513g [B]. 85.6g [C] 342 g D]. 1370 g

9. Calculate the molar mass of each of the following,

a) $CaBr_2$ b) $Ca_3(PO_4)_2$